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Editor

ROY WALDO MINER

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PROGRESS REPORT ON A NEW SCIENCE: THE GEOLOGY OF URANIUM DEPOSITS*

By DONALD L. EVERHART†

The extensive search for uranium deposits in the free world, which has now been under way for a decade, has been carried out by a vast cooperative team effort that is still continuing to grow. Many individuals and institutions have been involved in this effort. In the free nations, thousands of mining men in private industry, from individual prospectors to large, well-organized geological and engineering departments in great mining corporations, have participated. At the present time, the contribution of the U.S. Government to the job is indicated by the nearly 400 geologists, chemists, and physicists employed by the U.S. Geological Survey for work on uranium problems, and by the nearly 200 geologists, mining engineers, and other technical personnel hired directly by the U.S. Atomic Energy Commission. Other friendly governments are likewise contributing significantly. A large segment of the Geological Survey and Museum of Great Britain staff is assigned to exploration for uranium throughout the Commonwealth. Two Canadian government agencies, the Geological Survey of Canada and Eldorado Mining and Refining Ltd., have active technical staffs that carry out large programs. Australian and French government agencies also have employed sizable numbers of technical personnel in the search for uranium.

In the early period of the expanded search for uranium deposits, the techniques were, of necessity, dominantly empirical in nature. The vein matter and wall rocks of almost all types of metal deposits were tested for radioactivity, as were dumps in mineralized areas, and suites of mineral specimens in museums. In addition, of course, efforts were made to extend and enlarge known ore bodies whose uranium content was being mined for radium. Following the announcement of the government's need for new uranium discoveries and its bonus offers, many reports from widely scattered localities were received of new discoveries of radioactive deposits. This introduced the "fire-chasing" period when geologists and mining engineers were largely "on the defensive," investigating new finds as they were reported by others. Now, I believe, we are well into a third phase in our exploration work, in which scientific motivation is becoming important and the systematic use of principles is being applied to a positive type of search for deposits.

I believe that we cannot overemphasize the impelling need at this time for the ever-increasing application of scientific background in planning for uranium exploration.

In developing the science of uranium geology, we have, of course, established a working classification of known uranium deposits. Such classification can be done on the basis of several factors, but we have chosen, for the time being, to relate the various types mainly to the wall rocks involved. Such a classification is given in TABLE 1.

In the search for any metal, the historic procedure has been for emphasis to be placed, in the early phases of its usefulness, on the high-grade-ore deposits, with a natural progression in emphasis from higher to lower-grade sources as time goes on. Thus, our attention in the past decade has been largely focused on the relatively high-grade hydrothermal-vein deposits and the deposits in arenaceous sediments. In the future, no doubt, we shall be concerned more and more with the lower-grade uranium deposits in such types of formations as phosphorites, black marine shales, lignites, etc.

In the study of hydrothermal vein deposits, a broad pattern of geographic distribution and certain generalities concerning epochs of mineralization have emerged. Broadly, the deposits are concentrated in western Europe, western and central Africa, along the western margins of the Canadian Shield, and along the entire length of the Cordillera of North and South America. An exception to this is the new uraniferous province being explored in northern Australia. Three general epochs of uranium mineralization are known: one, in late pre-Cambrian or early Cambrian time; one at the end of Paleozoic time; and one in early Tertiary time.

Many of the pitchblende-bearing deposits be-

* This paper, illustrated with lantern slides, was presented at a meeting of the Section on January 5, 1953.

† Geologic Section, Division of Raw Materials, Atomic Energy Commission, New York.

long to Bastin's nickel–cobalt–native–silver type and are dominantly in metamorphic host rocks. The remaining deposits have certain other features in common, namely: simple mineralogy; pyrite and/or galena as the representative metallic minerals; silica or fluorite gangue; and granitic or monzonitic host rock. These deposits appear to constitute a second type of pitchblende-bearing deposit, which is described as the siliceous–pyrite–galena type.

Other features common to many of the hydrothermal vein deposits include the variable paragenetic position of pitchblende, the controlling influence of tensional fractures on pitchblende deposition, and the widespread association of pitchblende with hematitic alteration.

Uranium minerals are known from nearly all the pegmatite deposits in the United States but, in no case, have they been sufficiently concentrated to mine economically. This also appears to be true of other uraniferous pegmatites throughout the world; for example, in Ontario, Madagascar, Mozambique, India, Brazil, *etc.* The uranium in pegmatites is contained in accessory minerals, mainly uraninite, euxenite, samarskite, betafite, fergusonite, and thucolite. Uranium appears to have a special affinity for pegmatites rich in potassium feldspar.

The deposits in arenaceous sediments are divisible into three general types: carnotite deposits, so-called copper–uranium deposits, and asphaltite deposits. The carnotite deposits, which occur in sandstone and mudstone lenses of favorable permeability in continental sediments, are known in the western United States throughout a stratigraphic interval ranging from Permian to Eocene age. These deposits are known throughout the Colorado Plateau, in the hogbacks surrounding the southern part of the Black Hills of South Dakota, in the Powder River basin of Wyoming, and also in the vicinity of Mauch Chunk, Pennsylvania. Copper–uranium deposits, which are closely controlled by ancient channelways of the streams that laid down the continental sediments, are known throughout the southern part of the Colorado Plateau. The asphaltite deposits, which are similar geologically and which are frequently associated with the copper–uranium deposits, are known chiefly in the San Rafael Swell of Utah.

The problems of geologic control and origin of these uranium deposits in arenaceous sediments largely concern the wide stratigraphic span, the critical structural control exerted by the ancient channels, the association with organic trash, the critical sandstone–mudstone ratio, the matter of the ultimate origin of the uranium, and the complications brought about by secondary redistribution. In our exploration program for these deposits, our field procedures have been carried out in the light of two working hypotheses regarding the origin of the uranium, and therefore pertinent to the basic distribution of the ore bodies. One working hypothesis assumes a penesyngenetic origin, with the uranium being laid down in the streams at the same time as the enclosing sediments, or very shortly thereafter. This hypothesis involves a detailed study of the stratigraphy and sedimentation processes, a search for sources from old land areas, facies changes, *etc.* The second hypothesis assumes the introduction of later uranium-bearing solutions into the sedimentary column, with an extensive comingling of ground waters and the solvents which may have introduced the uranium into the rocks. One such natural solvent may have been hydrothermal (*i.e.*, juvenile) in origin, and this concept involves tectonic studies of the sub-sediment basement, relation of uranium deposits to vulcanism, physical tests on porosity and permeability of sandstones, and age determination studies. Another natural solvent may have been petroliferous in nature, and this concept leads to studies of the mineralogy and geochemistry of the uranium-bearing hydrocarbons and possible structural traps for these hydrocarbons.

TABLE 1
TENTATIVE CLASSIFICATION OF URANIUM DEPOSITS

1. Deposits in igneous and metamorphic rocks
   (a) Hydrothermal vein deposits*
   (b) Pegmatites
   (c) Disseminated deposits in igneous rocks
2. Deposits in sedimentary rocks
   (a) Deposits in arenaceous sediments
      (1) Carnotite*
      (2) Copper-uranium*
      (3) Asphaltite*
   (b) Deposits in calcareous sediments
      (1) Limestones*
      (2) Phosphorites*
   (c) Deposits in black shales
   (d) Deposits in lignites
   (e) Alluvial and placer deposits
   (f) Lacustrine-saline deposits

* Current producers.

Uranium deposits in calcareous rocks are known largely in the Todilto limestone of the Grants area, New Mexico, and in various phosphorites throughout the world. Within the United States, most attention on the phosphorites has been concentrated on the Hawthorne and Bone Valley formations of central Florida. Here, the uranium appears to be most concentrated in the upper "leached" zone of the Bone Valley formation, and the element appears to be largely in fluorapatite or collophane, replacing calcium.

Still-lower-grade concentrations of uranium have been noted in many of the black marine shales of the world and, in this country, our studies of the distribution and nature of these deposits have been concentrated largely on the Chattanooga shale of central Tennessee.

In summary, a consideration of the element uranium in the geochemical cycle of the earth's crust shows that its widespread occurrence, in many diversified geologic environments, is largely due to its following characteristics: (1) Solubility in both acidic and alkalic solvents; (2) affinity for carbonaceous material; (3) similar geochemical behavior to ferric iron; (4) solubility in natural ground waters, particularly in arid regions.

*SECTION OF BIOLOGY**

TRACER STUDIES IN THE BIOSYNTHESIS OF LIPIDS†

By SAMUEL GURIN‡

Recent *in vitro* evidence, obtained in a number of laboratories by means of radioactive precursors, indicates that long-chain fatty acids are biologically synthesized exclusively by way of some 2-carbon fragment. Glucose, lactate, pyruvate, acetone, short-chain fatty acids and ketogenic amino acids appear to be degraded into 2-carbon fragments prior to lipogenesis. Although C^{14}-labeled acetate is readily converted by rat- or cat-liver slices to long-chain fatty acids, slices obtained from livers of alloxan-diabetic rats or depancreatized cats are incapable of performing this transformation. If the hypophysis is removed along with the pancreas, lipogenesis by the resulting liver slices is again restored. The administration of growth hormone (free of ACTH) to such hypophysectomized-depancreatized animals inhibits lipogenesis when measured *in vitro* with liver slices.

From pigeon-liver homogenates, a water-soluble particle-free extract has been obtained that is capable of transforming C^{14}-labeled acetate into long-chain saturated fatty acids. Similar extracts prepared from liver homogenates of depancreatized pigeons are, however, incapable of lipogenesis. The addition of glycogen or hexose diphosphate to such inactive extracts restores lipogenesis to normal or nearly normal levels. These results, together with the experiments reported by Chaikoff on fasted animals, suggest that rapid glycolysis is a primary requirement for efficient lipogenesis.

Recently, it has been found possible to prepare an active water extract of rat liver that possesses lipogenic activity. Experiments are now in progress to determine the effects of glycolytic substrates upon liver extracts obtained from alloxan-diabetic animals.

* The Section of Physics and Chemistry held a meeting on January 6, 1953, at which a paper entitled "Clathrate and Other Inclusion Compounds" was read by Charles O. Beckmann. No abstract of this paper has been received.

† This paper, illustrated with lantern slides, was presented as part of the Symposium on Elucidation of Biosynthetic Mechanisms by the Use of Radioactive Tracers at the meeting of the Section on January 12, 1953. A paper entitled "Tracer Studies in the Biosynthesis of Porphyrins" was read by David Shemin as part of the Symposium at the meeting of the Section on January 12, 1953. No abstract of this paper has been received.

‡ Department of Physiological Chemistry, School of Medicine, University of Pennsylvania, Philadelphia, Pennsylvania.

SECTION OF MATHEMATICS AND ENGINEERING

LOW-FRICTION PROPERTIES OF AIR-LUBRICATED BEARINGS*

By DUDLEY D. FULLER†

An increasing need for bearings with unusually low friction has stimulated an interest in air-lubricated journal and thrust bearings. The fundamental relationships for such bearings are discussed and then applied to several examples taken from the fields of science and industry.

In recent months, there has been a sharp focusing of interest on bearings that are lubricated with air. This interest is centered around the two major advantages of the use of air: the first, freedom from contamination by the lubricant; and the second, low friction.

It is rather obvious that if air is substituted for oil or grease in a bearing, the danger of dripping, soiling, or contamination by the lubricant is completely eliminated. This is important in many applications dealing with food-processing machinery, thread and textile machines, and in the chemical industries. We will not be concerned here with this aspect of air-lubricated bearings. Rather, it is our purpose to describe the unique and sometimes amazingly low-friction properties of these bearings. We then plan to establish methods for the quantitative analysis and performance prediction of these bearings, based upon the fundamentals of fluid dynamics.

Air lubricated bearings are presently used over wide ranges of speeds, from very low to as high as 80,000–100,000 r.p.m. They have been designed as both journal bearings and thrust bearings and have been lubricated by the normal hydrodynamic action of air or by the hydrostatic introduction of air at elevated pressures. A considerable variety of designs is available to satisfy the needs of almost any type of application producing low-friction bearings with reasonably good load-carrying capacities. Certain designs have even been used to maintain extremely close running tolerances between machine elements, and one design of an air lubricated journal bearing has been used to measure pressures differences as small as 0.01 mm. of water.

This all began many years ago, near the end of the seventeenth century. It was then that Sir Isaac Newton conducted his great series of experiments.[1] One of these experiments was concerned with the resistance to motion of two concentric cylinders, when one cylinder was turned relative to the other, both being submerged in a liquid (FIGURE 1). Newton observed that, for a constant temperature, the frictional force was proportional to the relative speed of rotation and to the swept area, and inversely proportional

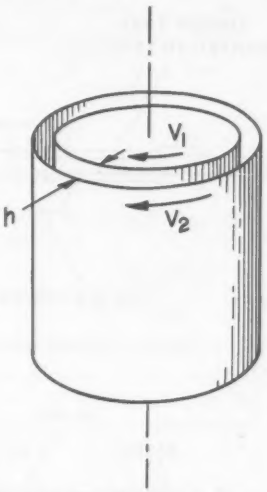

FIGURE 1. Newton's concentric cylinders.

to the radial clearance space between the cylinders, providing that this clearance space was small.

$$F = kA\,\frac{v}{h} \tag{1}$$

The constant of proportionality k depends upon the liquid and is now recognized as the absolute viscosity μ (mu). Thus, equation (1) may be written as:

$$F = \mu A\,\frac{v}{h} \tag{2}$$

As applied to a journal bearing of length l and radius r, A becomes $2\pi rl$, v becomes ωr, and the friction torque

$$T = F \times r$$

$$T = \mu 2\pi rl\,\frac{\omega r}{h}$$

$$T = \frac{2\pi r^2 l\mu\omega}{h} \tag{3}$$

* This paper, illustrated with lantern slides, was presented at a meeting of the Section on January 16, 1953.

† Department of Mechanical Engineering, Columbia University, New York.

where ω is the angular velocity in radians/sec., and h is the radial clearance in the bearing.

Albert Kingsbury,[2] and others have demonstrated the accuracy of equation (3) when applied to air-lubricated bearings. Kingsbury experimented with a bearing 6 inches in diameter and 6¼ inches long, in which was placed a short length of shaft weighing 50.5 lb. Radial clearance about 0.0008 inch. The load was carried without difficulty at shaft speeds above 250 r.p.m. Kingsbury measured coefficients of friction as low as 0.0010. Equation (3) can be used for air lubrication even when the bearing is carrying a moderate load of a few pounds per square inch, as long as a laminar flow condition prevails in the film. This is generally true if Reynolds number (VD/ν) for the film is less than 2000. ν is the kinematic viscosity of air; V is the surface velocity of the shaft; D is the air film thickness.

Example: A bearing 3 in. diameter by 4 in. long running in atmospheric air at a speed of 1800 r.p.m. and with a diametral clearance of 0.002 in. would have a friction torque as indicated by equation (3). Viscosity of air at atmospheric conditions = 0.018 centipoises or $1.45 \times 0.018 \times 10^{-7}$ lb. sec./in.[2] (Reyns)

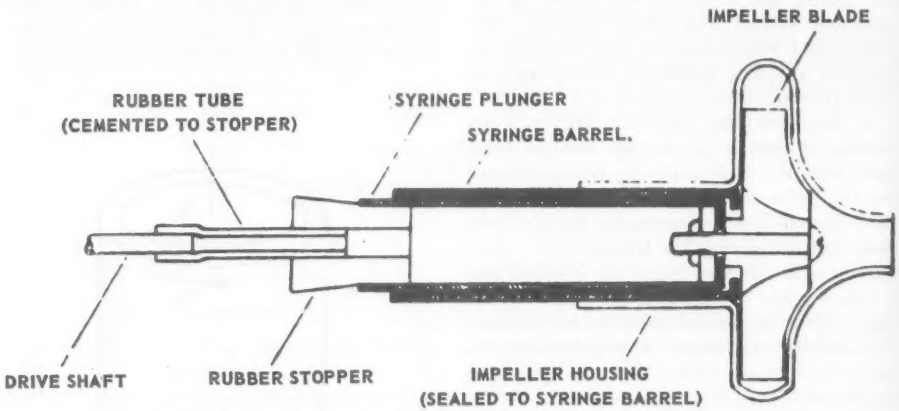

FIGURE 2. Hypodermic syringe used as pump bearing (Courtesy Rev. Sci. Instruments).

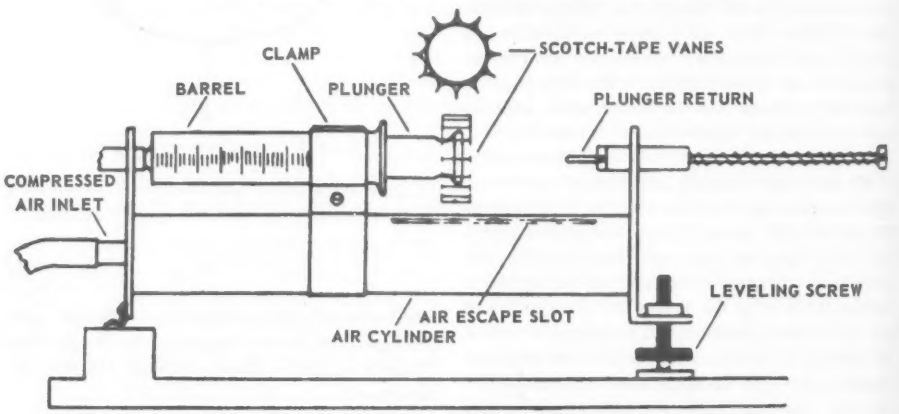

FIGURE 3. Hypodermic syringe used as pressure indicator (Courtesy Rev. Sci. Instruments).

$$T = \frac{2 \times \pi \times 1.5^2 \times 4 \times 1.45 \times 0.018 \times 10^{-7} \times \left(\frac{1800}{60} \times 2\pi\right)}{0.001}$$

$$T = 0.0279 \text{ lb.-in.}$$

$$\text{Friction horsepower} = \frac{2\pi TN}{12 \times 33{,}000}$$

$$= \frac{2\pi \times 0.0279 \times 1800}{12 \times 33{,}000} = \frac{1}{1260} \text{ h.p.}$$

An evaluation of the Reynolds number for the air film in this bearing would show:

$$R = \frac{\left(\frac{1800}{60} \times \pi \times 3\right) \times 0.001}{0.0232}$$

where the kinematic viscosity of air at atmosphere conditions is 0.0232 in.²/sec. $R = 12.2$, which is much less than 2000.

Surprisingly enough, first-quality air-lubricated journal bearings may be purchased very inexpensively at the corner drug store! The dry hypodermic syringe is actually an excellent journal bearing capable of running extremely well with air as a lubricant.[3] Brubach has used these syringes as bearings for small centrifugal blowers running at 6000 r.p.m. (FIGURE 2). Perhaps his most spectacular application has been in the measurement of gas leaks at very low pressures. FIGURE 3 shows the apparatus used for this purpose. The plunger of the syringe is caused to rotate by air impinging upon scotch-tape vanes. Due to this rotation, the plunger acts as an air bearing and is separated from the barrel by a hydrodynamic air film. Since the surfaces are separated by an air film, the force that is then required to move the plunger along the axis of the barrel actually approaches zero. Any slight change in the pressure of the line connected to the barrel will therefore produce an instantaneous axial movement of the rotating plunger. As an illustration of the sensitivity of this apparatus, it was connected to a tank of 100 liters capacity. Then 0.1 cubic centimeter of air was introduced into the tank. Immediately the plunger moved a corresponding 0.1 cubic centimeter. The theoretical pressure increase resulting from the injection of 0.1 ml. into 100 liters is about 0.0004 in H_2O or 0.01 mm. of water, and yet the low friction of the rotating plunger permitted it to respond instantly to this exceedingly small pressure differential.

Where thrust-type loads are encountered in machines and mechanisms, air can be frequently used as the lubricant. FIGURE 4 shows a model of a Kingsbury-type thrust bearing that runs very nicely on air. When the runner is turning the pivoted shoes tilt automatically until they develop a wedge-shaped film of air between the shoes and the runner, sufficient to carry the applied load. The runner in the model weighs 4 pounds and there are 3 shoes, each approximately 1½ inches square. Spinning the runner by hand provides more than enough velocity to support this load. Based on the hydrodynamic theory

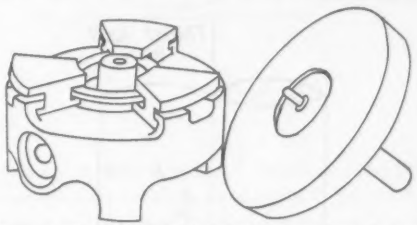

FIGURE 4. Model of air-lubricated Kingsbury thrust bearing.

an average value for the minimum film thickness under the shoes is:

$$h_o = \sqrt{\frac{0.066\ \mu v l}{Pavg}} \qquad (4)$$

where μ is the absolute viscosity; v is the mean linear velocity of runner; l is the length of the shoe in the direction of motion; $Pavg$ is the average loading pressure. The corresponding friction force would be:

$$F = \frac{0.75\ \mu b l v}{h_o} \qquad (5)$$

where b is the width of the shoe. For the model, with an average speed of 350 r.p.m., $b = l =$ 1.5 in.; mean shoe radius 1.75 in.; viscosity of air = 0.018 centipoise = $1.45 \times 0.018 \times 10^{-7}$ reyns (lb.sec./in.²); $v = 350/60 \times 2 \times 1.75 = 64.1$ in./sec.; area of 3 shoes 6.7 in.², $Pavg = W/\text{area} = 4/6.7 = 0.6$ p.s.i. In equation (4)

$$h_o = \sqrt{\frac{0.066 \times 1.45 \times 0.018 \times 10^{-7} \times 64.1 \times 1.5}{0.6}}$$

$h_o = 0.00017$ inch

The corresponding friction force, from equation (5):

$$F = \frac{0.75 \times 1.45 \times 0.018 \times 10^{-7} \times 1.5 \times 1.5 \times 64.1}{0.00017}$$

$F = 0.00166$ lb. per shoe

and the resultant coefficient of friction f, based on a mean shoe radius of 1.75 in.:

$$f = F/W = (0.00166)/(4/3) = 0.00125$$

Tests conducted on this model, measuring the rate of slowing down, give a value for the overall coefficient of friction, including windage, of approximately 0.002.

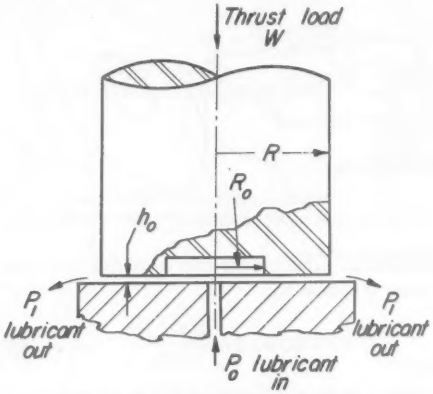

FIGURE 5. Elements of hydrostatic step bearing.

When it may be desirable to carry the imposed thrust load and separate the bearing surfaces at all times by a film of air whether there is bearing rotation or not, it is possible to introduce air hydrostatically under pressure. FIGURE 5 shows the arrangement of elements in such a bearing, called a "step" bearing. Equations (6), (7), and (8), based on the fundamentals of hydrodynamics, permit the evaluation of supply pressure P_0, volume of flow Q, and friction torque T. These equations are derived in Ref. 4.

$$W = \frac{P_o \pi}{2}\left[\frac{R^2 - R_o^2}{\ln (R/R_o)}\right] \tag{6}$$

$$Q = \frac{P_o \pi h_o^3}{6\mu \ln (R/R_o)} \tag{7}$$

$$T = \frac{2\pi\mu\omega}{h_o}\left[\frac{R^4}{4} - \frac{R_o^4}{4}\right] \tag{8}$$

FIGURE 6 depicts an interesting application to an ultracentrifuge, where the vertical load is supported on an air step-bearing and the rotor is spun by air jets. This unit operates at a speed of approximately 80,000 r.p.m. The friction is so low that, once the case is evacuated and the driving air supply shut off, the rotor will continue to spin for many hours before coming to rest. With $R = 3\frac{5}{8}$ in., $R_0 = 1\frac{1}{32}$ in., effective weight 1.86 lb., shaft diameter $\frac{1}{16}$ in., and subtracting the

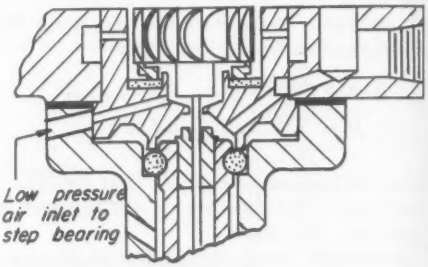

FIGURE 6. Air step bearing on ultracentrifuge (Courtesy The Sharples Corp.).

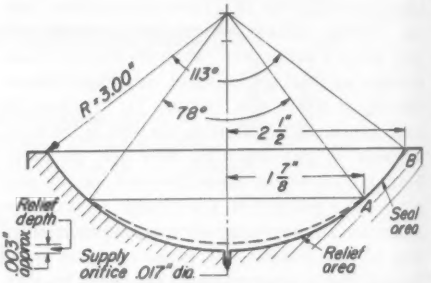

FIGURE 7. Details of air bearing (Courtesy Sperry Gyroscope Corp.).

shaft cross-sectional area from the load-carrying area of the bearing, in equation (6):

$$1.86 = P_o \frac{\pi}{2}\left[\frac{(3/8)^2 - (11/32)^2}{\ln 1.091}\right] - P_o\left[\frac{\pi\,(1/16)^2}{4}\right]$$

$$P_o = 4.62 \text{ p.s.i.}$$

Actually, 5 p.s.i. is used on this step bearing.

A very interesting model was built by the Sperry Gyroscope Company to demonstrate the low-friction properties of air-lubricated bearings. FIGURE 7 shows a steel ball 6 inches in diameter supported in a cup. Calculations of air pressure and volume required using equations (6) and (7) were completely substantiated by experiment. They were $P_0 = 2.1$ p.s.i. and with $h_0 = 0.001$ inch, Q was 0.02 cfm. The friction was so low that, once the ball was started spinning, it con-

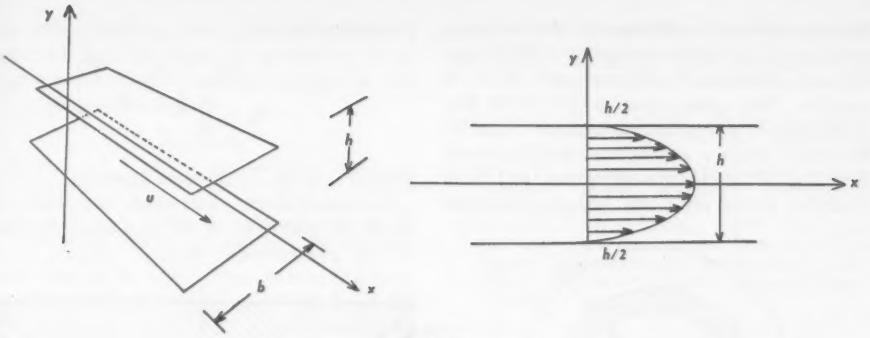

FIGURE 8.

tinued to rotate for hours. In reality it became a ball, freely suspended in space, turning without friction.

Hydrostatic lubrication itself generally leads to very low coefficients of friction, even with oil. A rather striking example is that of the Hale telescope on Mount Palomar, where the over-all coefficient of friction, using a medium viscosity oil, is 0.000004. This telescope, weighing about one million pounds, is rotated by a ½ h.p. clock motor, which actually supplies more power than is required.[5]

A recent design for an electrical dynamometer with a cradle weighing 1300 pounds,[6] reports a coefficient of friction 0.00000075. Actually, this is zero for all practical purposes, and was obtained with oil. Air under similar conditions would introduce even less friction.

It should be emphasized that the equations set forth here are based upon the hydrodynamic theory of incompressible liquids and can only be used with air if the pressures involved are not greater than a few pounds per square inch. Where greater loads are carried and unit pressures are higher the analysis must include the compressibility effect due to significant changes in volume as the air passes through the bearing.

As an example of this type of calculation, consider the step bearing again. Euler's equation for steady, one-dimensional flow with friction, neglecting the body forces of weight and inertia, is:

$$\frac{\partial P}{\partial x} = -\mu \frac{\partial^2 u}{\partial y^2} \tag{9}$$

in which P is pressure, μ is absolute viscosity, and $\partial P/\partial x$ the pressure gradient in the x direction, along which flow is being considered. u is the velocity in the x direction. Considering the flow through a slot of width b and height h (FIGURE 8), then $u = 0$ at $y = \pm h/2$, and $u = u_{max.}$ at $y = 0$. Integrating equation (9) with respect to y at a definite value of x,

$$\frac{\partial P}{\partial x} y = -\mu \frac{\partial u}{\partial y} + C_1$$

When $y = 0$, $u = u_{max.}$, and $\partial u/\partial y = 0, C_1 = 0$. Then

$$\frac{\partial P}{\partial x} y = -\mu \frac{\partial u}{\partial y} \tag{10}$$

Integrating equation (10) with respect to y at a definite value of x,

$$\frac{\partial P}{\partial x} \frac{y^2}{2} = -\mu u + C_2$$

When $y = \pm h/2$ and $u = 0$, $C_2 = \partial P/\partial x\ h^2/8$. Therefore,

$$\frac{\partial P}{\partial x} \frac{y^2}{2} = -\mu u + \frac{\partial P}{\partial x} \frac{h^2}{8}$$

or

$$u = -\frac{1}{u} \frac{\partial P}{\partial x} \left[\frac{y^2}{2} - \frac{h^2}{8}\right] \tag{11}$$

The volume through the slot at any point is

$$V = \int_{-h/2}^{+h/2} b u dy$$

$$V = -\frac{b}{\mu} \frac{\partial P}{\partial x} \int_{-h/2}^{+h/2} \left[\frac{y^2}{2} - \frac{h^2}{8}\right] dy \tag{12}$$

$$V = \frac{b}{\mu} \frac{\partial P}{\partial x} \frac{h^3}{12}$$

For the physical conditions of this problem, equation (12) should be prefixed by a minus sign, for as x increases, P decreases, and $\partial P/\partial x$ is negative. Now apply equation (12) to the flow in the floor of a step bearing (FIGURES 5 and 9). We observe that $b = 2\pi r$ and $x = r$ and, in general, $V = V_0(P_0/P)^{1/n}$, where n determines the type of expansion taking place. V_0 and P_0 correspond

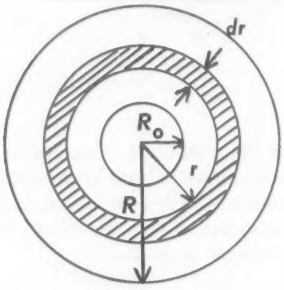

FIGURE 9.

to inlet conditions. h_0 is the film thickness. Then,

$$V_0\left[\frac{P_0}{P}\right]^{1/n} = \frac{-2\pi r h_0^3}{12\mu}\frac{\partial p}{\partial r}$$

Integrating with respect to r,

$$V_0 P_0^{1/n}\frac{12\mu}{2\pi h_0^3}\ln r = -\frac{n}{n+1}p^{n+1/n} + C$$

for $r = R_0$ and $P = P_0$. Therefore,

$$C = V_0 P_0^{1/n}\frac{12\mu}{2\pi h_0^3}\ln R_0 + \frac{n}{n+1}P_0^{n+1/n}$$

and

$$V_0 P_0^{1/n}\frac{12\mu}{2\pi h_0^3}[\ln r - \ln R_0] = \frac{n}{n+1}[P_0^{n+1/n} - P^{n+1/n}$$

Now assume isothermal expansion (constant temperature) and also when $r = R$, $P = P_1$. Then,

$$V_0 P_0\frac{6\mu}{\pi h_0^3}\left[\ln\frac{r}{R_0}\right] = \tfrac{1}{2}[P_0^2 - P]^2$$

and when $r = R$, $P = P_1$,

$$V_0 P_0\frac{12\mu}{\pi h_0^3}\left[\ln\frac{R}{R_0}\right] = [P_0^2 - P]^2$$

or, solving for V_0,

$$V_0 = \frac{\pi h_0^3}{6\mu \ln\frac{R}{R_0}}\left[\frac{P_0^2 - P_1^2}{2P_0}\right] \qquad (13)$$

where P_0 and P_1 are absolute pressures.

Equation (13) for compressible isothermal flow should be compared to the equivalent equation (7) for incompressible flow.

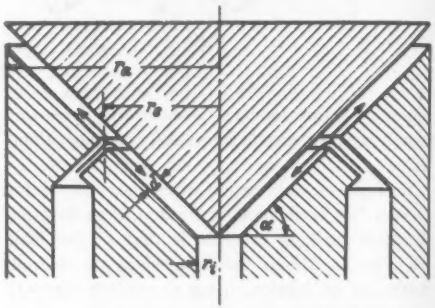

FIGURE 10. Air-lubricated bearing (Gottwald and Vieweg) (Courtesy Z. angew. Physik).

Some further considerations regarding air-lubricated bearings may be found in a recent German paper.[7] FIGURE 10 is taken from that paper and shows a conically shaped bearing supported by air under hydrostatic pressure. The air is supplied through the circumferential groove at the middle of the bearing or through a belt of holes at the same location. In reality, this is an elaboration of the step bearing described earlier. Before, with the simpler design, the air flowed only radially outward. With the design shown in FIGURE 10, the air flows both outward and inward. The authors have tested this and similar bearings and report good correlation between theory and measurement.

It should be obvious that air-lubricated bearings can be constructed in a number of forms to match the peculiar operating demands of a wide variety of applications. Air bearings have certain major advantages for many types of work. Within their limitations, then, they do represent a relatively new solution to the general problem of bearing design and analysis.

It is hoped that this paper has been able to make manifest the principles underlying this development, and perhaps point the way to further

uses and application. Our experience has already indicated that the range of application of air lubrication is limited only by the vision and imagination of the designer.

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SECTION OF PSYCHOLOGY

A PANEL DISCUSSION ON DIAGNOSIS AND THERAPY THROUGH PLAY*

By FRANCES S. ALEXANDER†

Dr. Murphy pointed out in her excellent paper that play is the language of the young child. I have been asked to emphasize play techniques with the age group 10–14 years of age. We can no longer say that spontaneous play is the language of the children of this age group. The cultural evaluation of work *versus* play has already become a part of the lives of these children or, rather, we should say that the kind of play that is acceptable as part of the subculture of this age group is quite different from the play of the young child. If you bring Susan, age 12, into the playroom and explain to her that this is the place where we are going to be together and that she can use the material in any way she wishes, it is quite likely that Susan will turn up her nose at the doll house and, if she feels free enough, say, "Those things are for babies!" She will say this even though, if you are a perceptive clinician, you can see that her eyes are gobbling up the doll families and the doll house. It may be very important for Susan's therapy that at some time she give in to her more infantile impulses and act out her conflicts with regard to the family situation with the dolls and the doll house, but she may take a long time before she is ready to do this. You may suggest to her that she might like to paint and she might accept this and start to draw for you a rather formal house or even copy something that she has been working on in the school art class. Again, it will take some time before she can paint freely. She feels the need to be grown up, and when one is grown up one does not play with dolls or mess with paints.

What I am trying to emphasize is the fact that the culture of the preadolescent has to be taken into account in describing how play techniques and therapy work with this age group. The interesting part of all this is the fact that these cultural standards, in a sense, are self-defeating for the child, because Susan's problem may well be that she is denying herself the satisfaction of immature impulses which are a focal point in her problem.

I should like to take a little time to discuss certain examples of Dr. Murphy's statement that each child uses symbols that evolve from his own personal experience, particularly pertinent to the discussion of the preadolescent. An illustration relates to the importance of competition in the age group that we are discussing. This is the time when competitive sports and playing fair become important to the youngster. In fact, he is likely to be rejected or accepted by his gang according to his ability to adopt their standards of competition. William, an 11-year-old, whom I treated for almost two years, was a severe behavior problem at home. He had very few friends and he was in continual conflict with his school gang. His relationship to his father was very difficult. William got to the point where he became so obstreperous in the play sessions that, for a time, I had to terminate the hour and set very definite limits upon his activity, particularly at one point

* This paper was presented as part of a Panel Discussion on "Diagnosis and Therapy through Play" at a meeting of the Section on January 19, 1953. At the Panel Discussion, papers were presented also by Lois B. Murphy and L. Joseph Stone. No abstracts of these papers have been received.

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where, after having cut up the chairs, he threatened me with scissors. He was very addicted to provoking rejection, which was one of his fundamental difficulties. In fact, when he had reached the peak of provocation and it was necessary almost every session to close the hour early, I offered him extra hours a week in order to make him feel that, even though limits had to be put on his obstreperousness, he himself was accepted. Over a period of eighteen months, however, there was slow, steady progress. Toward the end of therapy, one of the activities he was most interested in was a game that he played with me not in the playroom but in my office (It is not unusual that children towards the end of therapy want to leave the playroom and go into the therapist's office. Perhaps this is a sign of growth and development and of leaving childhood behind). William made paper airplanes and the idea of the game was that I was to stand near my desk while he stood opposite me at the other side of the room and I was to catch the airplanes that he tossed at me. When we first started this game, he threw them in places where it was impossible for me to get hold of them and I never made one point on the score. I interpreted to him that I felt he did not want me to win at all. We played this game for many weeks and finally William decided it was not quite fair that I never made a point, so he would express his concern over this and then throw me a few easy shots. At about the time we terminated, he was playing a fair game.

I have played many games of checkers with my child patients. For Murray, who could not lose, a chance victory of mine might mean changing all the rules, and changing them each time there was a chance I might win. For Elsa, who was shy and timid, I played as poorly as possible to let her have the success of winning. As Elsa grew in her selfhood, I played a fair game. Both Murray and Elsa learned to play fairly as we worked together.

Another child, Bill, was very concerned with money, again a value much accentuated in our culture. He was always trying to save up to buy some very expensive piece of equipment, such as a television set or a lathe. He tried bribing me, saying that he would behave himself in the therapy hours if I gave him a nickel. He was even given to such ruses as saying that he did not have carfare home so that he could get a nickel or a dime out of me. It is quite true that on one level this was Bill's way of controlling me. We must not neglect, however, to recognize that Bill was also working on his problems over money. How many of us adults have neurotic problems concerning money?

William, you will remember, is the child who played the game with the airplanes in my office. I should like to tell another very amusing incident concerning him, which illustrates another feature of this growth period. William, in spite of many problems, had considerable motivation towards growth. Baby talk, which was evident in the early hours of therapy, disappeared, as did crawling under my desk like a small infant. I have a tape recorder in my office and one of William's delights was to take recordings of himself. He was very perturbed one day, while listening to his recording, to note that his voice sounded rather high-pitched. I tried to explain to him that the way we hear our own voices is different from the way other people hear us. William was a very bright little boy, but he could not understand that he did not have a deep grown-up voice, and so we recorded and re-recorded, with William purposely making his voice deeper and deeper until he was finally satisfied that he had a deep man's voice.

What I have been trying to illustrate is this: The 10–14 year old will use cultural symbols as neurotic outlets. Money and competition are only two of these symbols. These social problems are features of the growth process of this age period. The preadolescent is coming to terms with the society in which he lives. In other societies, these symbols may not play such an important role. We are all concerned with more universal dynamic concepts, the need for love as expressed in oral needs, conflict with authority figures, *etc.* but, when we treat American children, we must be aware of the idiosyncrasies of American culture.

I should like to develop this theme a little more fully. Franz Alexander[1] has said that each person must come to terms with one feature of our society, which he calls "antagonistic cooperation." In his own words, "We are at the same time friends and rivals. These diametrically opposed principles of competition and cooperation are reflected in each individual as a personal conflict—one which he must settle for himself; and a successful solution in our present age is the exception

rather than the rule. The result is an overwhelming number of emotionally unbalanced persons." For instance, I have found that a most useful part of the play-therapy equipment is a punching bag. Perhaps it offers some children only a motor outlet for aggression. Some children will spontaneously symbolize what the punching bag means to them by saying, "This is the way I would like to hit my brother." I ask some children, "Whom might you be hitting?" but I do not press for an answer and sometimes I am quite silent. As a side point, I should like to point out that perhaps we have neglected to realize the importance of pure catharsis and motor outlets for anger.

Another illustration of ambivalence, and I think we might call it a case of "antagonistic cooperation," I take again from the case of Miriam. One morning, I was delayed in my schedule and was fifteen minutes late in beginning with Miriam. Miriam was usually ten minutes ahead of time. Miriam was angry and her conflict over her attachment to me and her anger at me was quite obvious. In fact, I helped her to verbalize her anger, but she worked it through in the hour in the following way. She drew a large heart on the easel with some pastels and spent the rest of the hour using this as a target for the toy pistol.

I should like to talk about one final point. Is it necessary for the child to know why he is coming to therapy? In the early years of my work with children, this used to worry me a great deal. I found if I asked the direct question, "Why do you think you are coming here?" that I rarely got a direct answer. If the child should ask me why he was coming, I would give him an honest explanation, usually in terms of some general statement such as, "Most children have difficulties in making friends or in getting along with their parents (as the case might be), and I thought perhaps you and I could talk about it and see if we can't make things easier for you." Even this did not help sometimes, because children would tend to deny that they had any difficulties. At the present time, I am not too concerned with this whole problem, although I have found that children who can verbalize some insight as to why they come show the best progress. One little girl put it this way. She said, "It is a funny thing, all I do is come here and play and now I make friends better." A little boy who had had a history of asthma and allergies made this statement at about the tenth hour of therapy. "It is a funny thing but every time I come here my nose runs." He had been engaged in building block towers and knocking them down with great gusto. He also liked to beat his own record of the number of times that he could punch the punching bag. His presenting symptoms were shyness, withdrawal, and retardation in his school work. Much later in the course of therapy his nose no longer ran when he released pent-up aggression, although he made no comment about it. I discharged him much improved.

If we are really honest therapists, we can admit to ourselves without loss of self-esteem that we really do not know what happens in therapy. I am convinced, as many other therapists are, that there are many subtle and illusive qualities in the relationship that account for therapeutic progress, but I am at a loss to know how to measure it. With children, of course, we cannot neglect the inherent process of growth and perhaps we as therapists, can only feel that we act as catalysts of nature's own process. Failures we have, too, although we are not so ready to admit them.

Let me close by emphasizing one thing that I think has been implicit in all the papers read tonight. Therapy with children has not been evaluated and validated to the extent that we can say that there is only one set of techniques to be used. Flexibility and a willingness to experiment can go on as long as we have a real respect for the child and as long as we provide him with a warm, accepting, empathic relationship.

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DIVISION OF MYCOLOGY

NUTRITIONAL STUDIES OF THE DERMATOPHYTES—EFFECT ON GROWTH AND MORPHOLOGY, WITH SPECIAL REFERENCE TO THE PRODUCTION OF MACROCONIDIA*

By RHODA W. BENHAM†

Studies in the nutrition of the dermatophytes were undertaken with the hope that the knowledge so obtained would help in improving both isolation and identification techniques. From the time of Sabouraud,[1] it has been known that the dermatophytes are a variable group of fungi and that the growth characteristics are modified according to the type of medium used. This fact led Sabouraud to devise two "Proof Media," and a conservation medium prepared from specified brands of peptone, crude glucose, and crude maltose. He published exact descriptions of the gross and microscopic characteristics of numerous species when grown on these media. Subsequent workers then used these same media for identification of their cultures. After World War I, however, it became impossible to obtain the ingredients for these media and substitutes had to be found. A search was made for a standard medium that could be used by all workers. The result was the dried powders now produced by the commercial houses. While it is advantageous to have the various workers in the field using comparable media, it was soon discovered that the above-mentioned media were not satisfactory if we were to increase our knowledge and understanding of the dermatophytes. Sabouraud grouped the dermatophytes on the basis of the clinical picture for which each was responsible and, to some extent, by their appearance in tissue. Gross characteristics were important in identification of the isolates obtained. His media were devised chiefly to obtain typical colony forms. But, as was pointed out by Emmons,[2] the morphological and biological characteristics of these fungi form a sounder basis for identification. Emmons's classification included three genera based on the characteristics of the macroconidium. Although other characteristics, such as colony formation, pigment production, and hyphal structures are an aid in identification, this classification of Emmons has emphasized the greater importance of the spore structures, especially the macroconidium or "fuseaux." That the different species of dermatophytes vary greatly in their ability to produce these spores has long been recognized. Langeron[3] and co-workers, realizing the inadequacy of the media in common use for the study of microscopic structures, introduced the so-called natural media, such as rice, barley, and wheat grains. These were found more favorable for the production of spores. Media long used by the plant pathologist, that is corn meal, potato, and wort agars, were also found more satisfactory for this purpose. All this led us to believe that a more accurate knowledge concerning the nutritional requirements of these fungi would be helpful. We are indebted to Dr. Robbins[4, 5, 6] and his co-workers for much of the initial work with the dermatophytes. By his and other studies, the dermatophytes have been shown to be heterotrophic organisms, some requiring for growth definite vitamins and, in two instances, a specific amino acid. These facts alone have made the isolation of the organisms in question more certain. Further, it has shown that no one medium is adequate for the study of the dermatophytes and that the same medium will not serve the same purpose for each species. I shall summarize the facts, particularly in regard to the production of the macroconidium, that have come from our laboratory as a result of nutritional studies.

Perhaps, at this point, it might be well to review briefly the characteristics of the dermatophytes as a family. They were originally distinguished from other fungi by their pathogenicity. In parasitic life, they flourish only in keratin-containing tissue, the skin and its appendages. They show some general similarity in colony form and microscopic structures. With one exception, they all produce round or pyriform microconidia, and the majority produce multicellular macroconidia. These are characteristic for the genus in which they occur and form, as mentioned above, the basis for Emmons's[2] three genera. Species can be distinguished only by a combination of characteristics, such as minor differences in the macroconidia, differences in the form and arrangement of the microconidia, and by such

* This paper, illustrated with lantern slides, was presented as part of the Symposium on Nutritional Studies of the Dermatophytes at the meeting of the Division on January 23, 1953.

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mycelial structures known as spirals, nodular organs, "chandeliers," "antlers," and pectinate hyphae.

The three genera now recognized are, *Microsporum*, *Trichophyton* and *Epidermophyton*. In *Microsporum*, the macroconidium is a large, septate, spindle-shaped structure with a thick wall, whereas, in *Trichophyton*, this same structure is somewhat smaller and has a thinner wall. The shape varies from long pencil-shaped structures with parallel walls to short club-shaped forms with walls indented at the septae. The ends may be somewhat pointed, but are often rounded. The third genus, *Epidermophyton*, has shorter, club-shaped structures, with thin walls and fewer cells. They are usually grouped, often in bananalike clusters.

The microconidia in *Microsporum* are, for the most part, rare and occur along the sides of the hyphae in what we speak of as *en thyrses*. In *Trichophyton*, they are more abundant and occur both *en thyrses* and on a branched conidiophore, forming a grapelike cluster, which is termed *en grappe*. In some species of *Trichophyton*, the *en thyrses* type predominates. In others, the *en grappe* and, in a few, both types occur with equal frequency. Microconidia are entirely lacking in the genus *Epidermophyton*.

The other microscopic structures vary greatly in the frequency with which they are seen, and are definitely characteristic for some species; for example, the "chandeliers" of *Trichophyton schoenleinii*, the *favus* organism; the spirals of *Trichophyton mentagrophytes*; and the pectinate hyphae of *Microsporum audouini*.

The macroconidium production has been definitely shown to be influenced by the ingredients of the culture medium. In the genus *Microsporum*, for example, there are three species, two of which, *canis* and *gypseum*, produce the macroconidia in great abundance on the usual media. The third species, however, *M. audouini*, produces them rarely if at all on these media. That this is a deficient organism is evidenced by the fact that it will not grow on sterilized rice grains, whereas *canis* and *gypseum* will. It will be remembered that Benedek[7] found that a culture of *M. audouini* on polished rice grains, when it became contaminated with a bacillus that he named *Bacillus weidmaniensis*, not only grew well, but produced long, thick-walled, septate and nonseptate, spindle-shaped spores. We were able to confirm this observation. Further, Hazen[8] was able to show that, if Sabouraud's honey agar was enriched by the addition of yeast extract, there was a marked increase both in the vegetative growth and in the production of macroconidia. The effect upon macroconidial development was comparable to that of *B. weidmaniensis*. It might be assumed from these findings that the substances produced by the bacillus were in the nature of vitamins. Further work,[9] however, has not supported this assumption. No one factor was found that induced abundant macrospore formation in all strains.

The genus *Epidermophyton*, in which but one species, *Epidermophyton floccosum*, is recognized, produces macroconidia in abundance on the usual media. A lack of microconidia and a paucity of other hyphal structures, however, led us to believe that nutritional studies might be of interest here.

Mrs. McCormack undertook such a study with several typical strains of *E. floccosum* isolated at the Vanderbilt Clinic. She has reported one very interesting result in a recent number of the Journal of Investigative Dermatology.[10] The finding of tightly coiled spirals similar to those seen in *Trichophyton mentagrophytes* was indeed exciting. They occurred in two of the eight strains selected for study, but only on cornmeal- and potato-dextrose agars. Here, there would seem to be two factors in force, both a strain and a medium difference. The factor controlling the formation of spirals definitely needs further study. Contrary to our expectations, only one of the eight strains studied proved to have a definite deficiency. This strain and a white mutant arising from it failed to grow, except in the presence of yeast extract, neopeptone, or bactopeptone. The vitamins and amino acids to be found in yeast extract were added individually and in combination to a basal medium of the following formula:

$MgSO_4 \cdot 7H_2O$	0.1 g.
Dextrose, reagent grade	40.0 g.
Sorensen's m/15 phosphate buffer mixture to give a final pH of 7	100.0 ml.
Purified agar	20.8 g.
Distilled water	800 ml.

In no instance did they permit growth of this strain or its mutant. It must then be concluded that some unknown factor present in the yeast extract or in the complex proteins is required by

this strain. Further studies with a larger number of strains of the genus *Epidermophyton* are indicated.

The genus *Trichophyton*, due to the larger number of species and the great variability occuring within a species, presents greater difficulty in the matter of identification and classification. For convenience, the genus is divided into subgroups, which now number five; namely, (1) *gypseum* group, (2) *rubrum* group, (3) *crateriform* group, (4) *rosaceum* group, (5) *faviform* group

Each group then contains a number of species and closely related variants. In the first two groups of the *Trichophyta* are found the two most common causes of ringworm of the hands and feet.

Trichophyton mentagrophytes, the type species of group 1 differs from *T. rubrum*, the type species of group 2 in many respects, not the least being in the formation of the macroconidium. As a rule, *T. mentagrophytes* forms macroconidia on all of the usual media, with wort agar serving particularly well for this purpose. *T. rubrum*, on the other hand, rarely forms macroconidia on any of the usual media, but forms them almost to the exclusion of microconidia and other hyphal structures on a heart infusion agar. Tryptase seems the important factor in this case.[11] This one fact has been of considerable help in distinguishing between the two species.

Georg,[12] working in our laboratory, has shown that the faviform *Trichophyton* is definitely stimulated by enriched or whole grain medium with the production of vigorous growth and both macro- and microconidia. The species *T. verrucosum*, which includes the varieties *album*, *discoides*, and *ochraceum*, was shown to require inositol and thiamine for growth, a fact that has been a great help, not only in the isolation of this species but in maintaining it in our stock culture collection. *Trichophyton violaceum*, another member of this group, was found by Georg[13 14] to require thiamine for growth, and macroconidia were obtained for the first time on a thiamine-enriched casein agar. Ten strains of *T. violaceum* all reacted the same in this respect. One strain, which differed in that it produced a white, downy growth with no pigment, was found to need the amino acid l-histidine for growth, but not the vitamin thiamine. This was the first instance in which a dermatophyte was shown to require a specific amino acid for growth. That this isolate was *T. violaceum* was definitely proved by a reversion to the parent type, with production of pigment. This pigmented strain, was shown to have lost the amino acid requirement and to have become thiamine deficient.

Finally, two organisms, long confused in the literature, *T. megnini*, for which *T. rosaceum* Sabouraud 1909 is a synonym, and *T. gallinae*, *Epidermophyton gallinae* of Megnin 1881, have now been clearly defined and established as distinct species as a result of nutritional studies both by our laboratory[15] and by Georg.[16] Macroconidia are formed abundantly by *T. gallinae*, particularly on casein and yeast extract agar. *T. megnini*, on the other hand, forms microconidia abundantly and few macroconidia. We have observed them on Sabouraud dextrose and honey agars, but more easily on the heart infusion agar. Georg[16] reports that spore production was enhanced for this species on media rich in amino acids, such as trypticase–dextrose agar. These two species appear so distinct that it may become necessary to place them in separate groups, giving us six sub-groups instead of five. Before proposing such a change, however, we should like to obtain for study a larger number of isolates of *T. gallinae*.

A grouping of the dermatophytes, as at present recognized, is shown diagrammatically in FIGURE 1. Due to the knowledge obtained from nutritional studies, this grouping differs somewhat from that given in Conant's manual of clinical mycology and in other texts. No changes are noted for the first two groups, however, as there has been no extensive study made of the numerous varieties included in the gypseum group, nor of a sufficient number of isolates of the rubrum group to warrant any reorganization. In the rosaceum group, *Trichophyton megnini* and *Trichophyton gallinae* are given as distinct species, whereas *T. gallinae* is usually given as a synonym of *T. megnini*.

Following the suggestion of Carrion and Silva,[17] and in agreement with our own observations, the crateriform group has a reduced number of species. *Trichophyton tonsurans* is given species rank, with *crateriforme*, *acuminatum*, and *cerebriforme* falling in synonymy. The second species is *Trichophyton sulfureum*, which a number of recent investigators believe distinct. Further studies are to my mind necessary for establishing this fact. Dr. Georg is at present making a study of

a large number of isolates of this group and will no doubt clear up the situation.

The faviform group has been stated to contain four species (1) *Trichophyton schoenleinii*, with *T. concentricum* a probable synonym; (2) *T. ferrugineum*; (3) *T. violaceum* with one variety, *glabrum*; and (4) *T. verrucosum* with the varieties *album*, *discoides* and *ochraceum*. Following the suggestion of Ainsworth and Georg,[18] the species name *faviforme* originally suggested by Georg[12] has been dropped in favor of *verrucosum*, the legitimate name by priority. These few instances will serve to indicate the influence nutritional studies may have upon the identification and classification of the dermatophytes. The role played by the culture medium upon the production of macroconidia points to the need of a more extensive study of this important structure, with the hope that we may learn more about the nature of these spores and the manner in which they form.

The macroconidium varies in its characteristic form not only for the genus but for the individual species within the genus, and thus constitutes one of the very important criteria in identifying isolates. The determination of the nutritional requirements of the individual species and their variants and its effect upon the morphology of the same continues to be an important phase of the study of the dermatophytes.

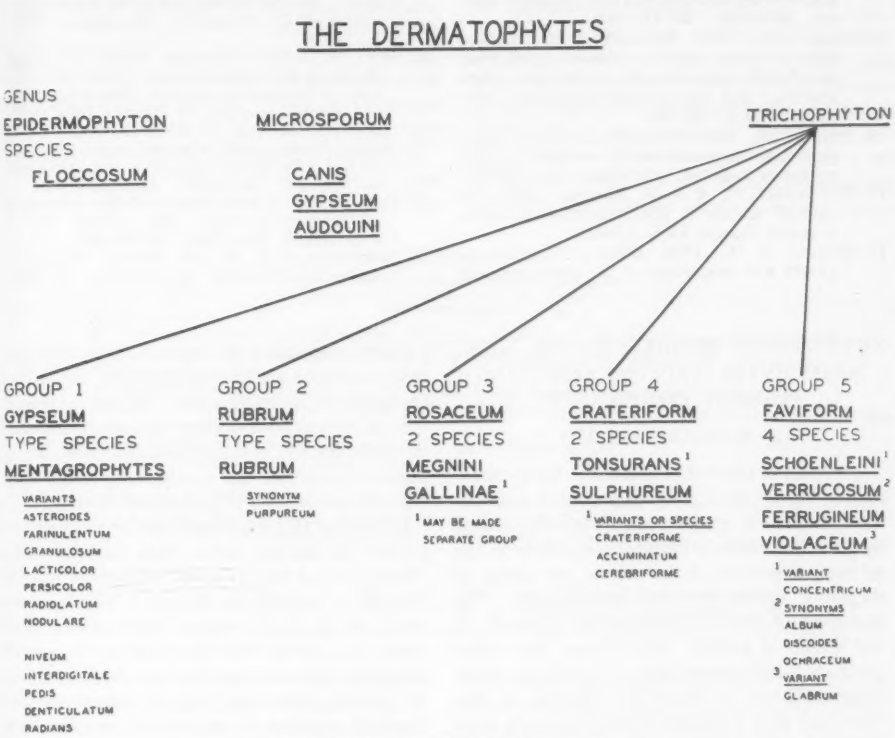

FIGURE 1. A tentative grouping of the dermatophytes.

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NUTRITIONAL STUDIES OF THE DERMATOPHYTES—FACTORS AFFECTING PIGMENT PRODUCTION*

By MARGARITA SILVA†

The study of pigment production in the dermatophytes is a subject of practical as well as academic interest. The bright-colored substances produced by these pathogens in culture, particularly in the submerged portion of the colony, are useful as diagnostic criteria for their identification. The biological functions of dermatophyte pigments are not known at present, but evidence from other groups of fungi suggests that some of these colored compounds may be respiratory pigments, or that they may have a protective function, such as an antibiotic action or the screening of harmful light rays. Possibly, these pigments may also be related to the virulence and invasive power of these pathogens or to the chronicity of the lesions produced.

Before these roles can be determined, however, more accurate information must be obtained on the chemical structure and properties of the pigments and on the requirements and mechanisms for their production. Chemical studies of dermatophyte pigments have been undertaken in the past by various investigators (Tate, 1929; Thompson, 1943; Maechling, 1949), who reported that the pigments they extracted behave as pH indicators, have a reduced and an oxidized form and are of the nature of anthraquinones. We are far from a definite identification of these substances, however, no doubt due to the complexity and variability of pigment production and to difficulties in the isolation and purification of the colored compounds.

It is hoped that nutritional studies will help this problem in various ways. They may determine whether or not the variability in pigment production can be controlled by the use of suitable culture media of chemically defined composition. They might also furnish information as to the specific nutritional precursors required for the biosynthesis of pigment, and thus help in determining the chemical structure of the colored compounds, as well as their role in the metabolism and survival of these pathogens. Some information is already available. The studies of Lewis and Hopper (1941) showed that the presence of a suitable carbohydrate, like glucose, is required for pigment production in *Trichophyton rubrum*, maltose being inadequate for the same purpose. In addition to a suitable carbon source, a suitable nitrogen source is also important. This was shown by Bocobo and Benham (1949), who reported that pigment production in *T. rubrum* will not take place when the nitrogen source is ammonium chloride, even if glucose is present, and also by Robbins and Ma (1945), who showed the influence of amino acids on the pigments produced by *Trichophyton mentagrophytes*.

These observations have been confirmed and

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extended by the studies to be reported tonight, which include various isolates of four species of *Trichophyton*, namely *T. rubrum*, *T. mentagrophytes*, *T. Megnini*, and *T. gallinae*, listed in TABLE 1.

These fungi were studied on both complex and chemically defined media. Complex media such as those usually employed in the study of dermatophytes were used in order to observe the various pigments produced on these media by the fungi being studied. Chemically defined media were employed in order to study the effect of vitamins and of various nitrogen sources, including individual amino acids, on the pigments produced.

The results obtained with the routine mycological media permitted comparison of the color to rose colored. The reverse of the colony can vary from colorless to amber to brownish-wine-red It is this latter type of isolate that can be confused with *T. rubrum* and must be distinguished from it on the basis of microscopic morphology. Inoculation into cornmeal agar to which two per cent dextrose has been added may be helpful in this connection (Bocobo and Benham, 1949).

(4) Both *Trichophyton gallinae* and *T. Megnini* produce colonies on Sabouraud's dextrose agar whose aerial mycelium is initially white but later becomes pigmented—a delicate pink, in the case of *T. gallinae*; an intense rose color in the case of *T. Megnini*. The submerged mycelium of the latter species attains a very intense brownish-red coloration that does not appear to extend beyond

TABLE 1
CLASSIFICATION AND ORIGIN OF ISOLATES

(A) *Trichophyton rubrum*
C-1 and C-12, isolates from Vanderbilt Clinic, Columbia-Presbyterian Medical Center, 1949 and 1950
C-6, C-7, C-8, isolates from Dr. Carrion's laboratory, Puerto Rico, 1946, 1947, 1948
(B) *Trichophyton mentagrophytes*
C-2, "red-pigment-producer", isolated by Dr. Lucille Georg, Chamblee, Georgia, 1949
C-9, isolate brought by Dr. J. Gardner Hopkins from Dr. Sabouraud's laboratory in Paris in 1948, labelled "*Trichophyton lacticolor*"
C-10, isolate labelled "*Trichophyton farinulentum*." Same source as C-9
C-13 and C-14, isolates from Vanderbilt Clinic, 1950
(C) *Trichophyton Megnini*
C-11, isolate brought from Dr. Sabouraud's laboratory, Paris, 1948, labelled "*T. rosaceum*, strain Gaillard"
C-16, isolate from C. B. S., Holland, received from Dr. Elizabeth Hazen, 1950
C-20, C-21, C-22, C-23, isolates obtained in 1950 from Dr. Rivalier, Hôpital St. Louis, Paris—strains Baticle, Leendert, Oscar, and "W," respectively
(D) *Trichophyton gallinae*
C-15, isolate brought in 1948 from Dr. Sabouraud's laboratory, labelled "*Sabouraudites gallinae*"
C-24, isolate obtained in 1950 from Dr. Rivalier, strain "P," also labelled "*Sabouraudites gallinae*"

production of these four species of dermatophytes and an appraisal of the differences in hue, intensity, distribution, and diffusibility of the pigments produced. These observations were, in general, confirmatory of previously published descriptions, and may be summarized as follows:

(1) Of the various complex media tested, Sabouraud's dextrose and honey agars were found the most suitable for maximum color display on both the aerial and submerged portions of the colony.

(2) On these media, *Trichophyton rubrum* produces a deep wine-red coloration on the reverse of the colony that remains confined to the area occupied by the submerged mycelium. The aerial mycelium may be either white (downy) or pink (velvety), depending on the type of isolate.

(3) *Trichophyton mentagrophytes* produces a greater variation in colony types on these two media, the aerial mycelium in some isolates being white, in others cream to beige, and in others pink the limits of the colony; whereas *T. gallinae* produces a diffusible pigment that extends beyond the area occupied by the mycelium and tints the entire substrate a deep strawberry-red.

In general, it may be said that these four species of *Trichophyton* are capable of producing red-, wine-, or rose-colored pigments in cultures on the complex media usually employed by medical mycologists. The expression of color, however, varies not only with the individual isolate and with its genetic stability but also, to a large extent, with the culture medium on which it is grown. Since these media contain complex substances, variations may occur between different batches of media and result in variations in the quality and intensity of the colors displayed by a given isolate.

For this reason, studies with chemically defined media seemed indicated, so that various nutrients could be evaluated for their influence on pigment production. Since media containing

peptone, a complex source of nitrogen, seemed to be the most favorable for the development of color in these four species, it was considered pertinent to attack the problem by testing simpler sources of nitrogen singly and in various combinations.

A "double strength" basal medium was prepared with the following formula:

$MgSO_4 \cdot 7H_2O$	0.1 g.
Dextrose, C. P.	40 g.
Sorensen's *M*/15 phosphate buffer mixture to give a final pH of 7	100 ml.
Distilled water, to make	500 ml.

To this "double strength" basal medium, nitrogen sources and vitamins were added singly and in various combinations from Seitz-filtered aqueous solutions, the volume of the medium then being brought up to one liter with distilled water. For solid media, 2 per cent powdered "Difco" agar was added after "purification" by prolonged washing in water, extraction with pyridine, alcohol, and acetone, and air-drying in an oven at 50°C. Cultures were made on solid media in test tubes inoculated with tiny washed fragments of mycelium and maintained in an incubator at 27°C.

A preliminary test was made in order to compare the effect of inorganic *vs.* organic nitrogen sources in the presence and absence of vitamins. For inorganic nitrogen, ammonium chloride and ammonium nitrate were used in a 0.2 per cent concentration; for organic, asparagin (0.2 per cent) and a vitamin-free casein hydrolysate (0.1 per cent) were employed. These four media were prepared with and without vitamins. When vitamins were added, a mixture consisting of seven vitamins in the following concentrations per liter: 500 μg. each of thiamine hydrochloride, riboflavine, pyridoxine hydrochloride, calcium pantothenate and niacin; 10,000 μg. of inositol and 50 μg. of biotin, was used. The results obtained with these media are summarized in TABLE 2.

It was found (1) that the addition of vitamin did not affect the quality or intensity of the colors produced by any of the four species studied; (2) that the development of a rose or red color occurred only when the source of nitrogen was organic, in this case, asparagin or casein. It is of interest to note that although *T. gallinae* developed a pink color when grown on asparagin, it produced only a neutral-brown pigment on casein. Since casein contains an adequate amount of asparagin, the question arises as to whether or not some of the other amino acids contained in casein may be inhibitory for the production of the pink color.

In order to determine more precisely how various amino acids would affect pigment production, subsequent tests were made using groups of four or five amino acids at a time, singly and in various combinations, and in graded amounts to supply a total concentration of 12.9 mg. N per 100 ml. of medium. This concentration is equivalent to the total nitrogen supplied by the 0.1 per cent casein previously employed.

The results obtained with individual amino acids are summarized in TABLE 3, in which it will

TABLE 2

COLORS DEVELOPED ON INORGANIC *versus* ORGANIC NITROGEN SOURCES WITH AND WITHOUT THE ADDITION OF VITAMINS

Organism	*"Vitamin-free" Media**			*Same media plus seven* vitamins*
	Inorganic nitrogen sources NH_4Cl NH_4NO_3	Organic nitrogen sources		
		Asparagine	Casein	
T. rubrum 5 isolates	Pale to dark amber-brown	Bright red	Bright red	Addition of vitamins had no visible effect on either growth or pigments developed
T. mentagrophytes 2 'red' isolates	No pigment	No pigment	Bright red	
T. Megnini 6 isolates	No growth	No growth	Bright red	
T. gallinae 2 isolates	No pigment	Pale pink	Neutral brown	

* Basal medium and vitamin additions detailed in text.

be seen that the four species had different amino acid requirements for pigment production. This observation is significant, since it shows a fundamental difference in the choice of precursors for pigment biosynthesis by different dermatophyte species, and this difference may be an indication that the pigments themselves have different molecular structures.*

The results with media combining several amino acids further suggested the possibility that certain amino acids may actually inhibit the synthesis of the pigmented substance. Thus, in a medium containing histidine, leucine, lysine, and proline, *T. rubrum* produced a less-intense wine-red pigment than it did on any of the last three amino acids when employed alone (TABLE 3). Since no pigment had been produced on histidine alone, it was suggested that this amino acid might be inhibiting the utilization of leucine, lysine, and proline. Similarly, with *T. gallinae* it was noted not only that lysine permitted good color formation (TABLE 3) but also that, when this amino acid was used in combination with the other three, its concentration determined the amount and intensity of the diffusible pigment produced. *T. Megnini*, on the other hand, produced a more-intense red pigment when lysine was omitted from this combination of amino acids.

A study was also made comparing the relative value of solid and liquid media for the detection of pigment. Several variations in the method of preparation of the media were tested for their effect on pigment production with the following results:

(1) The method of sterilizing the amino acids, whether by filtration or by autoclaving, had no effect on the quality or intensity of the pigments produced.

(2) If the glucose to be added to the basal medium is sterilized separately and added to the medium at the time of dispensing it, two advantages are derived: (a) the caramelization which takes place when the glucose is autoclaved with the medium, is prevented, thus permitting a better detection of colors; and (b) the usual lowering of the pH of the medium during autoclaving is avoided.

(3) For studies of pigment production, a larger amount of inoculum can be employed than is necessary when determining the ability of an organism to utilize a given substrate for growth. The larger amount of inoculum that can be dispensed with a graduated pipette in measured amounts from a thoroughly washed suspension of ground fungus material permits more rapid growth and therefore a much earlier detection of color without altering the quality or intensity of the pigments produced from a given amino acid.

(4) For the development of pigment in a liquid medium, it was found that a large surface area, a shallow layer of liquid, or aeration of the culture by constant agitation increased pigment production. With stationary cultures, a surface mat of mycelium is produced, pigment developing in the undersurface. In agitated cultures, on the other

TABLE 3

COLORS DEVELOPED* ON MEDIA CONTAINING SINGLE AMINO ACIDS AS SOLE NITROGEN SOURCES

Amino acid	Organisms			
	T. rubrum 5 isolates	*T. mentagrophytes* 2 "red" isolates	*T. Megnini* 6 isolates	*T. gallinae* 2 isolates
Asparagine	Bright red	No pigment	No growth	Pink to medium red
Alanine	Light to medium brown	Neutral medium brown	No growth	No pigment
Arginine	Light to medium brown	Warm medium brown	No growth	Strawberry pink
Glycine	Light to medium brown	Amber	No growth	Pink†
Valine	Light to medium brown	Wine-red	No growth	No pigment
Histidine	No pigment	Light to medium brown	Pale yellow to orange	No pigment
Leucine	Intense wine-red	Light to medium brown	No growth	No pigment
Lysine	Intense wine-red	Light to medium brown	No growth	Pale to intense pink†
Proline	Intense wine-red	Light to medium brown	No growth	No pigment

* Color in undersurface of colony except where otherwise indicated.
† Diffusible pigment.

* Additional evidence to the effect that more than one pigment (chemical substance) is produced by dermatophytes has been disclosed by the work of Dr. John C. Wirth, who informs us that his investigation of the pigments of *Trichophyton rubrum* shows that there are at least two and possibly several pigments involved. Further work is in progress to obtain these fractions in crystalline form.

hand, the fungus does not form a surface mat but grows in the form of the familiar submerged pellets, pigment appearing not only on the pellets themselves and in the ring of mycelium formed on the wall of the flask at the highest level reached by the agitated liquid, but sometimes also dissolved in the liquid medium itself. It was found that *T. rubrum* produces a brick-red pigment, which goes into solution when the fungus is grown in a liquid medium containing dextrose and any of the suitable amino acids. This is an interesting finding since, in cultures grown on agar media, it is difficult to determine whether or not the pigment produced in the submerged mycelium extends at all beyond the area occupied by it. It may be that solubility of this pigment is increased by agitation in a liquid medium.

Further studies are being conducted with a greater number of isolates of each species in order to confirm and extend the above observations. It is hoped that studies of this kind will contribute to an understanding of the mechanisms of pigment production, help in the isolation and characterization of the pigments and, eventually, permit a determination of the biologic functions performed by these colored compounds for this important group of pathogens.

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SECTION OF ANTHROPOLOGY

THE MUTUAL INTERESTS OF ARCHEOLOGY AND ECOLOGY, WITH EXAMPLES FROM MIDDLE AMERICA*

By GORDON F. EKHOLM†

Our interest here is in the general problem of the relationship of human cultures to their environments, seen from the point of view of the archaeologist and of the ecologist, and a discussion of the ways in which each may contribute to the other's line of inquiry.

We shall limit our discussion to the archaeologically known history of Middle America. I shall assume that we all know something of the difficulties of evaluating the factors of tradition, history, climate, soils, *etc.*, which mold the form of any one society, even if the functioning of that society can be observed at the present time and we have ample records of its past history. To do the same for a large complex unit of culture history, such as Middle America, known solely through archaeological techniques, greatly multiplies the difficulties. The record will be incomplete—partly speculative—and subject to varying interpretations. It does, however, give us a broad view of the relationship of culture to environment, especially as regards changes through time.

Perhaps, I might best initiate our discussion by outlining our present knowledge of Middle American culture history, taking note as I proceed of those problems that seem to me to have most reference to ecological or geographical factors. In this, I shall rely heavily on the map and chronological chart (FIGURES 1 and 2).

Looking at the map, the major cultural subdivision is that of Mesoamerica, bordered on the north by a line running through northern Mexico, and on the south by a line through western Honduras and then parallel to the Pacific Coast down to and including the Nicoya Peninsula. At the time of the Spanish Conquest all of the peoples living within this area were agricultural with certain cultural forms in common and distinct from those outside the area. We conceive of Mesoamerica as having had much this same unity from at least as early as late Preclassic times.

Northern Mexico appears to have had throughout a relatively sparse population of hunting and gathering peoples. This area is quite arid and infertile and we might safely postulate that the sharp demarcation here of civilized from uncivilized was largely the result of environmental factors. Beyond the southern boundary of Mesoamerica lived peoples having their primary

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cultural affiliation with South America. This boundary is less certain and with no obvious geographic explanation.

FIGURE 1.

not definitely fixed, and showing them as straight lines on the chart is not meant to imply that the same changes occurred everywhere at the same time. Charts of this kind are a mixture of both working hypotheses and demonstrable space–time relationships.

Preclassic. The relatively simple cultures of the Preclassic have been found stratigraphically below those of Classic and Postclassic date in all the major sub-areas of Mesoamerica, but the earliest and simplest of them appear to have been based on maize agriculture and a settled community life. A duration of 1500 years for the Preclassic, beginning at approximately 1500 B.C., is derived from two radiocarbon dates for the Valley of Mexico. Though not certain, these dates push back the beginning of the Preclassic only about 500 years beyond the guess dates of the archaeologist

	1 Central Mexico	2 Oaxaca	3 Gulf Coast	4 Olmec	5 Highland Maya	6 Lowland Maya
1520 A.D.						
Postclassic	Aztec	V	Local cultures	Local cultures	Quiche	Mexican absorption
	Toltec	IV				Mexican Period
900 A.D.						
Classic	Teotihuacan	Monte Alban III	Tajin	Middle Tres Zapotes La Venta	Pamplona Amatle Esperanza	Tepeu Tzakol
1 A.D.						
Preclassic	Ticoman Tlatilco	II	Panuco I, II	Early Tres Zapotes	Miraflores Zacatepequez	Chicanel
1500 B. C.	Zacatenco	I			Las Charcas	Mamon

FIGURE 2.

Within Mesoamerica the major centers of cultural growth apparently lie in Central Mexico, Oaxaca, several points in the Gulf Coast region and in the highland and lowland Maya areas. Though not equally important or of the same importance through time—or even considered primary by all specialists—they serve, however, to make an important point, *i.e.*, that major centers occur in both the rainforest regions of Yucatan and the Gulf Coast and in the highland regions of Guatemala and Mexico.

Though undoubtedly an oversimplification, it is now customary among workers in the field to divide the Pre-Columbian history of Mesoamerica into three major periods. It seems to fit the observed stratigraphic sequences in the various local areas and the relationships between them, and to provide a means of viewing major developmental trends. It is probably correct in general, but the points of division between periods are and those suggested by De Terra on the basis of geological and climatological studies. On the later horizons in several sub-areas, large pyramidal structures grouped in the manner of Classic-Period ceremonial centers indicate a development during these 1500 years from a stage of simple village life to that of the full-scale Classic pattern. With these gradual changes it is difficult to fix the end of the Preclassic. The Maya specialists are inclined to use 325 A.D., which is the earliest date inscribed on a stela, converted according to the Goodman-Thompson correlation. This is somewhat arbitrary. We could hardly expect the earliest date we find to be the earliest date recorded or to be a particularly significant one in the many cultural changes occurring at this time.

The widespread occurrence of certain figurine styles and a certain uniformity in culture presuppose either common origin or considerable communication between the several sub-areas, though

the rarity of trade items makes accurate correlation difficult in the Preclassic. Further research should make it possible to integrate the sequences more completely and indicate the possible place of origin of the Preclassic pattern.

The problems concerning the origin of the Preclassic cultures are among the most interesting and important for not only Mesoamerica but the New World as a whole. Though but recently begun, intensive search for "early man" sites in Mesoamerica has resulted in the finds of Tepexpan man, the Ixtapan mammoth skeleton associated with stone artifacts and two distinctive stone industries. There remains, however, a complete gap between these simple hunting cultures and the earliest of the Preclassic cultures, in which the growing of maize and cotton, pottery making, and weaving are already well established. Those pondering these problems have usually postulated a developmental stage during which the "early man" hunters and gatherers learned to cultivate plants, to make ceramics, and otherwise underwent the changes aptly described for the Old World as the "Neolithic Revolution." This assumes, of course, that these were independent developments in the New World, a point of view I am not prepared to accept, though I cannot provide a logical explanation of how they were transmitted from the Old World. The present lack of developmental sites, however, does not to my mind prove their nonexistence. I am well aware that explorations are sketchy in many parts of Latin America, and I realize also how deceptively meager the remains of complex cultures can be. It could be, too, that cultures of the Preclassic kind came into Mesoamerica from farther south in Central or South America, though no traces have yet been found there. Further field work coupled with careful analysis of the basic problems is necessary and particularly in working on this horizon, the archaeologist can benefit from close cooperation with the geographer or ecologist and with those botanists interested in the history of the cultivated plants making their appearance at this time.

Classic. The Classic Period (1–900 A.D.) sees Mesoamerican civilization at its peak. It includes the Classic Maya (formerly known as the Old Empire), the Teotihuacan culture of Central Mexico, Monte Alban III, Tajin, La Venta, *etc.* Many great ceremonial centers with large temple and palace structures and an emphasis on stone sculpture characterize the period. During this time, astronomy, the calendar, and the arts reached a high point. The labor represented by the great structures, accomplished without the help of draft animals or advanced mechanical aids, is tremendous. This obviously means large populations and, doubtless, a typically theocratic organization with a concentration of power in the hands of a few. It was probably a time of relative peace, for sites lack defensive works and the art is, in general, nonwarlike. Kidder has suggested that the political organization of the Lowland Maya may have been a loose federation of autonomous city states, and this may possibly apply to other areas as well. There appears to have been a greater regional variation in cultures during the Classic Period than either before or afterwards, as seen in the quite distinctive architectural and sculptural styles of the Maya, Olmec, Zapotec, or Teotihuacan areas. Here is the best opportunity, perhaps, to see some subtle adaptations to the varying ecological situations in which these traditions were at home.

The developmental history or place of origin of the Classic pattern is little known. It may well have been a process of cross-fertilization with no one center of pre-eminent importance. Perhaps, also, Old World civilizations provided a stimulus. There is some reason to think, however, that the Olmec culture in the lowlands of the southern Gulf Coast may have been a primary center; skilled jade carving and monumental sculpture with calendrical inscriptions may be earlier here than elsewhere. This suggestion is opposed by those who believe that the highland areas were more suitable for intensive agriculture, with resulting food surpluses necessary to larger populations and the specialized activities of more advanced cultures. I personally favor this point of view, in the absence of definite evidence opposing it, because it is more consistent with what we know of civilizational processes in the Old World. The high culture of the Lowland Maya seems strangely unsuited to its environment, and may well have been transplanted from a more favorable locality.

The disintegration or destruction of the Classic cultures has often been attributed to climatic change or other environmental causes. Speculation has been rife, but no one explanation has received general acceptance. Armillas has suggested that the maintenance of a huge theocratic

organization made exorbitant demands on the producing population and brought about an economic-social crisis. Soil erosion or climatic changes may have been contributing factors. To invoke climatic change as a cause, perhaps we must explain how it would operate in both the tropical forest and highland regions. This is necessary unless we assume that a breakdown of the social system in one area could have sown the seeds of revolt in the others.

Postclassic. For the period of 900–1520 A.D., our archaeological knowledge is less complete, but we can supply additional evidence from Spanish descriptions and native historical accounts.

The presence of fortified towns, the scenes of warfare in paintings and reliefs, and the content of the written histories referring to this era suggest a greatly increasing militarism. In Central Mexico, the Toltec of Tula superseded the Teotihuacan culture and were, in turn, replaced by new groupings, consolidated in the 14th and 15th centuries into the Aztec Empire which, eventually, controlled much of Mexico. The Monte Alban IV period in Oaxaca, apparently a decadent form of Classic Zapotec, was replaced by the Mixtec who, more than any other people in Mesoamerica, maintained or revived the artistic standards of the Classic Period. The Classic Maya centers of the Peten were going back to bush, but combined Maya and Toltec strains maintained a cultural center at Chichen Itza. This disappeared at about 1200 A.D. and only vestiges remained when the Spanish arrived. The Olmec culture apparently ceased to exist by the end of the Classic, and the Tajin culture dissolved somewhat later. Local cultures lacking in individual flare held sway until the Conquest.

I have repeatedly cited the lowlands and highlands as being the two most significantly different ecological zones in Mesoamerica, and the Postclassic picture may have resulted from these differences. The tropical lowlands are either deserted or support cultures, which only echo those located in the highlands. Is the environment the critical factor in the situation?

In this rapid survey, I have been discussing culture wholes and the major ebbs and flows in Middle American culture history. The picture is tentative, but perhaps will be significant to those looking at it from another point of view than that which limits the vision of an archaeologist.

THE INTERDEPENDENCE OF ARCHEOLOGY AND ECOLOGY, WITH EXAMPLES FROM MIDDLE AMERICA*

By PAUL B. SEARS†

The ecological relationships of man express themselves in the forms of his cultures. Culture and environment are thus functionally related. Anthropologist and ecologist alike are students of process and therefore deeply concerned with the dimension of time. The work of the archeologist in reconstructing past cultures from their physical evidence is an essential aspect of paleoecology. In turn, the paleoecologist, by his work on the sequences of past environments, can be useful to the archeologist in rounding out the rationale of his findings as well as in giving some help on technical problems of stratigraphy.

Progress has been somewhat complicated, yet perhaps stimulated, too, by the existence of certain schools of determinism, climatic, economic, cultural, and biological. The key, of course, lies in the idea of limiting factors with which the ecologist must constantly deal. In processes that have many components, the equilibrium at any given time is likely to be such that a single component, or a simple combination, is decisive, as in the French Chamber of Deputies with its many parties, where the vote of a relatively small group may serve to turn the balance. The trouble is not with determinism, but with the failure of determinists to understand how complex are the dynamics with which they must deal.

This is evident in the work of Huntington (1922) on climatic changes. Aside from the fact that many of the direct data he needed were not at hand as they are now, his concepts of culture and civilization were too simple, and he seems to have been largely unaware of the problem of soil erosion due to improper land use and the whole accompanying disruption of the water cycle. The fact that we know better now should not lead us to disparage the very great value of his work. Time and the advance of knowledge may put us all in the same boat with him eventually.

* This paper was presented as part of a Symposium of the same title at a meeting of the Section of Anthropology on January 26, 1953.

† Conservation Program, Yale University, New Haven, Connecticut.

There is an old saying in the journalistic rat race, "Be good to the people you pass on the ladder as you go up. You may meet them later on your way down."

Meanwhile, of course, there are many striking and familiar examples of the mutual benefits of archeology and ecology. Keller's (1878) thorough reconstruction of the Swiss Lake Cultures and the climatic evidences from animal drawings in the caves of southern Europe need no comment. In Europe, the intensive study of bog deposits and their correlation with late- and post-glacial events, including the changes in the Baltic area, have led to archeological interpretations of the highest value (Godwin, 1934). The excellent collaborative study of the Boyleston Street fishweir (Johnson, 1949) in Boston is perhaps the best-known work of the kind in North America. In Michigan, Cain and Anderson now have an unpublished sequence of vegetation and climatic change extending from a time soon after the retreat of the last local ice down into the period of modern agriculture.

These more detailed and refined types of evidence have been made possible by the method of pollen analysis, to which I shall give the chief emphasis during the remainder of my discussion.

Spores and pollen grains are among the most resistant of fossils. While pollen that depends upon insect transport is rare and sporadic, that which is scattered by wind is abundant and representative of the dominant vegetation in most instances. Lake sediments preserve it systematically throughout the life history of the lake, on into the bog stage where it is a component of peat, from which it is easily separated for identification and counting. The changing proportions of pollen from different genera and families (less frequently species) in successive layers reveal the shifts of past vegetation and so of climate.

The separation of pollen and other spores from sediments other than peat, such as silts, sands, and clays, sometimes involves considerable technical difficulty. Fortunately, the materials of most intensive archeological interest have been "post-glacial" and peat is abundant in the lakebeds of this period.

The first step, both for the ends of pollen analysis and those of archeology, is to establish the characteristic pollen profile for any region under investigation. This gives the sequence of vegetation and climate throughout a given period of sedimentation. Using this as a working basis, general stratigraphic relations of fossil soils, alluvial deposits, and archeological horizons are set up. Without thorough preliminary work of this type, it is difficult to be of service to the archeologist.

Once such a profile is obtained, it becomes possible:

(1) To assign a stratigraphic position to any isolated archeological find which may have lacustrine sediments adhering to it. Relatively small amount of peat, silt, or clay (at most a few cc.) suffice to establish the pollen spectrum and fit it into place in the profile.

(2) To establish the prevailing conditions of vegetation and climate associated with any culture whose stratigraphic position is firm.

(3) Where a succession of cultures has occurred, to assign them to position on the pollen profile and, by comparison of such profiles in different regions, to establish the contemporaneity of cultures. By this means, for example, the existence of Tardenoisian culture in southern Germany at a time when the Maglemosian prevailed in Scandinavia has been shown. (Godwin, *l.c.*)

(4) By the use of cereal pollen and that of ruderals, such as plantain, wormwood, amaranths, chenopods, *etc.*, that associated with forest clearance and primitive agriculture to determine the onset and continuance of such activities (Iverson, 1949)

In "The Archeology of Environment" (Sears, 1932), I reviewed what was then available regarding cultural successions in the Missippi Basin and Northeastern States in the light of pollen sequence. An effort was made to predicate the type of culture most favored by the successive types of vegetation and climate. In particular, I postulated as most favorable to the spread of the high mound culture the known northeastward shift of optimum conditions for maize culture, which must have occurred during the xerothermic, or warm–dry maximum, circa 500 B.C.

One feature of this paper that seems to have been lost in the shuffle was an approximation of the order of magnitude of the dates involved. This was based upon the finding of laminations in certain peats from which I derived a conventional constant of peat growth rate for the Erie Basin of about 300 years to the foot. Two years later we (Sears, Janson, 1934) confirmed this estimate by observing the rate of compression of

fresh peat in which the annual layers could be separated, and by determining the depth to which spruce needles from trees of known age could be recovered in peat.

On this basis, I fixed the climax of the warm–dry xerothermic at about 3000 years ago and the revertence to more humid conditions somewhere more than 1000 years ago. These estimates tally well with Carbon-14 results, and also with cross-dating from our recent work in Mexico, while my dating of the spruce-fir period (lake Mankato) in the north-central states at around 10,500 years is in line with the results of C-14 findings, which have run close to 11,000 years, Our subsequent studies in the basin of Mexico show that, except during periods of vulcanism, or when erosion is intensified by tectonic activity, human interference and, perhaps, extremely arid climate, the deposition of lake sediments tends to occur at a remarkably uniform rate.

In this 1932 paper was included a prophetic suggestion by my colleague Dr. Forrest E. Clements that the distinctive pollen of maize should be sought for in American sediments—a possibility first realized by Dr. Edward S. Deevey Jr. (1944). He recovered it, along with the pollen of agave, in the upper sediments of Lake Patzcuaro. Dr. Deevey, in his report, also outlined the potentialities of pollen analysis for Mexican archeology.

It became my good fortune, in 1948, during a visit to Mexico, to receve the active encouragement and assistance of Dr. Pablo Martinez del Rio, Director of the Institute of History and Anthropology; of Ing. A. V. Arellano of the Institute of Geology; his chief, Dr. Mongez Lopez; his colleague, Dr. Manuel Maldonado-Koerdell; of the ecologist, Dr. Faustino Miranda; of Dr. Helmut de Terra, then operating under a grant from the Viking Fund; Dr. Rubin de Borbolla, Director of the National Museum; and of Dr. Sanchez Morroquen, of the Polytechnic Institute, as well as other generous friends. Through them, I was able to collect and analyze, with field help from Sres. Arturo Romano and Luis Aveleyra, samples of sediment from the basin of Mexico and to correlate them with significant archeological horizons.

In broad outline, the sequence of events in the Basin of Mexico was known. The heavily fossilized remains of Peñon Man (Aveleyra 1950) found by Castillo in 1844, although pointing to great antiquity, had been discounted by Newberry; a judgment hard to support if one has viewed the specimen. De Terra (1949) reported the discovery of Tepexpan man in a stratum indubitably filled with mammoth remains. This was again discounted by authorities north of the Rio Grande, and some unfortunate difficulties of technique gave color to the objections. De Terra had also discovered very primitive artifacts of the Chalco industry at the highest ancient beach levels, well above the later zones of occupation.

Below these El Risco beaches (2258–2265 meters) various archeologists had described in considerable detail the remains of Archaic or Upper Middle Culture, as at El Arbolillo (2250 meters) and Zacatenco (2248 meters) and ranging thence downward to the site at El Tepalcate, north of Chimalhuacan (2235 meters). This last site, submerged in Aztec times, has been exposed by recent drainage and appears to represent the end of the Middle Culture.

The next phase is the Teotihuacan, at 2266 meters and some 30 kilometers northeast of Mexico City, whose first phase is identical with the last of the Archaic and has been assigned a date of about 500 B.C. It is known to have persisted to about 800 or 900 A.D. with elaborate developments that have been described conveniently by Vaillant (1941). Unquestionably, it represented a shift of the cultural center from low to high elevation.

The final phase is that of the Nahua, marking a return to the lower basin with Tenochtitlan (now Mexico City) as its ultimate center under Aztec rule, at 2236 meters. The accompanying economy was lacustrine, supplemented by skillfully terraced hill farming.

Given this sequence, the question naturally arises what, if any, environmental changes might have been involved. Fortunately, the key afforded by pollen is cleancut. It comes from the surrounding mountains, where oak and alder occupy the moister sites, with fir at higher elevations. Pine, in general, occupies the less humid sites. Consequently, the plotting of oak–alder–fir against pine gives the relative moistness of climate.

Again, fortunately, the late Archaic site at El Tepalcate is overlain with coarse volcanic ash that can be traced as a stratigraphic marker under subsequent sediments. Profiles obtained at a number of points agree in placing this ash layer

in a period of extreme dryness; a fact consistent with the then minimum lake level (Sears 1952).

The profiles also show that this was the culmination of a long period of slow drying following an irregularly marked, moist interval. This fits the gradual lowering of lake levels during the Archaic period.

Above the ash layer, there has been considerable disturbance by oxidation and human activity. In three of my ten profiles, which appear to be fairly normal, there is evidence that the dry climate persisted for some time after the Late Archaic, *i.e.*, into the Teotihuacan period. But in all of the profiles, save two that are truncated, there is evidence of a strong return of moist conditions near the top. In two, these moist conditions can be definitely correlated with Nahua artifacts, and this can be extended to the remainder by reasonable inference, as well as by the known higher lake level at the time of the Conquest.

Thus we know that two great waves of lacustrine culture in the lower part of the basin, the Middle or Archaic from 2000 to 500 B.C. and Nahua from 800 or 900 A.D. through the Conquest were separated by a long dry interval, as indicated by the upland forest composition. During this interval, the center of cultural activity was on higher ground, at Teotihuacan, where presumably ground water, supplemented by rainfall, was available.

The same phenomenon of movement to higher ground, following desiccation of a lake, took place in western New Mexico, in the San Augustin Plains area, where the maizegrowers of Bat Cave lived along the plata margin. Numerous sites well above this level have been studied. All are more representative of cultures more recent than that of Bat Cave and are near sources of ground water.

One of the very old problems of Mexican archeology is that of the abandonment of Teotihuacan, which had obviously been a great and powerful center. Vaillant (*l.c.*) had suggested that it might have been involved with legendary crop failures and drying of streams due to deforestation, since immense amounts of lime had to be burned to supply the plaster so lavishly used on the elaborate structures there. Cook (1949) later found evidence of severe erosion during the period of greatest activity at Teotihuacan, a reasonable consequence of deforestation.

How long the intensely dry conditions of 500 B.C. persisted, remains to be established. There is reason to believe, however, that the climate became moister again some centuries before Teotihuacan was abandoned, alsough the northern portion of the valley is markedly drier than the southern. Renewed vitality of the cultures lower down and farther south, attendant upon the rise of lake level, is a factor to be reckoned with. But the upland site must have been vulnerable so far as water supply is concerned, and any stripping of the forest cover above it would have had profound effects on the water economy. I suggest that the ground water sources that made possible its original development suffered greatly, despite the increase of moisture toward the end. Excavation has revealed elaborate devices for the interception of rainwater, but it may be doubted whether these were at all adequate.

We know from the comments of Enrico Martinez (1606) that deforestation and grazing by the Spaniards had immediate and serious effects in the valley. Forests had apparently recovered during Nahua time. On the whole, my findings lead me to concur strongly with Vaillant, although I would place less stress on local crop failure in the immediate region of Teotihuacan, which apparently drew tribute from a wide area, than upon the direct consequences of water famine at the immediate site. The establishment there was immense and its requirements high. The end came at a time of general improvement in moisture conditions, but the secondary effects of human disturbance must have been serious, even so, while the vigor of the lacustrine cultures farther south is not to be questioned.

If it can be shown that the climatic changes just described were general in character, we may infer that the extreme desiccation around 500 B.C., which persisted for some time thereafter, would have favored cultural expansion into the humid tropical forest regions; while the humid reversal, which grew in intensity following the 9th century A.D., would almost certainly have the opposite effect.

No pollen profiles from the Mayan regions are available as yet. We have, however, good evidence that the climatic changes in question, and others of like magnitude for a long antecedent period, were general in scope. Through the good offices of Ing. ARV Arellano of the Instituto de Geologia and Dr. Leonardo Zeevaert, a profes-

sional soil engineer, we have practically continuous deep cores from two sites under the present City of Mexico, which give a concordant record extending well back into the Pleistocene (Sears, Clisby, 1952). These, in turn, agree with a deep core from northern New Mexico placed at our disposal by Dr. H. T. Stearns. The laborious and meticulous work of analysis was performed by my associate, Kathryn H. Clisby of Oberlin College. Equally thorough work on the sedimentary record has been done by Professor Fred Foreman of Oberlin, so that we shall presently have a valuable account of the history of the Basin. These studies have been made possible by the Wenner-Gren Foundation and the Geological Society of America, and we have now ready for analysis, through help from the National Science Foundation, a continuous core to a depth of 645 feet—almost thrice that of the preceding cores—from western New Mexico.

It is our hope that these extensions backward in time from the better known archeological zones will ultimately be of service in interpreting the growing evidence of much earlier man in North America. With the evidence we now have and the methodology developed by Mrs. Clisby, relatively little work should be required to place El Mamut de Ixtapan and its stone points in their place on the scale.

I should like also to mention the finding by Mrs. Clisby of abundant maize pollen to a depth of nine meters, corresponding to early Archaic, under the City of Mexico. On this basis, we had hopes of tracing the origin and movement of maize culture by a systematic study of Latin American sediments. Later, however, she found a number of grains at a depth of 75 meters, far below any known level of human activity. These grains are now under study by our colleagues at Harvard. All of the evidence to date indicates that these ancient pollen grains are those of maize, and we await the final verdict with considerable interest. They are either maize or a close relative and differ definitely from teosinte. At any rate, we may be sure that the problem of this plant is far more complex than we had hoped it would be.

As a final word, while I hope it is evident that the ecologist can be of service in reconstructing the past of mankind, I am especially anxious to register the deep obligation of the ecologist, who, in his task of reconstructing and interpreting the total environment, has found the stimulus and assistance of the archeologist invaluable. In particular, the work of correlating late glacial history and vegetation, now approaching its solution, would have been long delayed without the evidence afforded by cultural stratigraphy and chronology.

Since the preceding manuscript was prepared, Miss Wolfe, working with Dr. Barghoorn at Harvard, has determined that the deep-level grass pollen has the morphometric characters of maize rather than those of its closest relatives. These results will be published shortly in the Harvard Botanical Leaflets.

I should also like to emphasize that our conventional constant for the rate of peat growth in the Erie Basin must be used with great caution, especially where peat growth has been interrupted.

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SECTION OF OCEANOGRAPHY AND METEOROLOGY

STUDY OF TURBULENT DIFFUSION BY ATMOSPHERIC EDDIES*

By MAYNARD E. SMITH†

Much of the current interest in atmospheric turbulence stems from an increased recognition of the seriousness of the air-pollution problems found in many cities and near industrial plants. This concern over air pollution is now so widespread that there is an intense demand for practical solutions to the many problems involved. For meteorologists, the demand often takes the form of a request for simple engineering formulas to predict the dispersion from specific installations.

As our understanding of atmospheric turbulence increases, it becomes more and more obvious that oversimplified solutions are likely to be misleading, because of the complex effects of plant aerodynamics, effluent characteristics, and terrain and meteorological factors. Even identical installations on similar terrain may have significantly difierent air-pollution problems as a result of unlike microclimatology.

The oil-fog studies conducted at Brookhaven National Laboratory are reviewed to illustrate the wide variation in dispersion conditions resulting from meteorological factors alone. The fact that the distance of maximum ground-level concentrations under unstable or neutral conditions ranges from 1 or 2 stack heights to more than 50 stack heights is emphasized. Also of great importance is the extreme deviation from isotropicity found with stable air, in which the vertical eddies are so completely suppressed that effluent from an elevated source does not reach ground-level, even at distances of many hundred stack heights.

The horizontal component of the wind gustiness has been used at Brookhaven as an indicator of the type of dispersion. These gustiness classes are closely related to the vertical temperature structure and, to a lesser extent, the wind speed. The seasonal and diurnal distributions of the gustiness show clearly that there are two predominant types of dispersion, one characteristic of the night hours and the other of the day. Remarkably little seasonal variation is found. Identical distributions may not be expected at other sites, especially because of the sea-breeze circulation that is so prevalent during the warmer months.

It is certain that meteorological and terrain factors are sufficiently variable to preclude the use of a very simple means of predicting the characteristics of pollution from a particular installation. When consideration is given to the fact that each plant has a unique combination of effluent characteristics, stack parameters, and plant aerodynamics, it becomes obvious that a thorough analysis of all factors is necessary to achieve acceptable results.

* This paper, illustrated with motion pictures and lantern slides, was presented at a meeting of the Section on January 27, 1953. Research carried out under the auspices of the U. S. Atomic Energy Commission.

† Brookhaven National Laboratory.

CONFERENCES HELD

SECTION OF PHYSICS AND CHEMISTRY

"BRANCHED MOLECULES"

JANUARY 9 AND 10, 1953

The Section of Physics and Chemistry held a Conference on "Branched Molecules." Doctor Frederick R. Eirich, Polytechnic Institute of Brooklyn, Brooklyn, New York, was the Conference Chairman in charge of the meeting.

The program consisted of the following papers:

Friday, January 9

Morning Session. Chairman: P. J. Flory

"Introductory Remarks," P. J. Flory, Cornell University, Ithaca, N. Y.

"Physical Properties of Solutions of Branched Polymers," Bruno H. Zimm, General Electric Company, Schenectady, N. Y.

"Statistical Mechanics of Dilute Solutions of Branched Polymers," Walter Stockmayer, Massa-

chusetts Institute of Technology, Cambridge, Mass.

"Application of Viscosity Methods to the Study of Branching in Polysaccharides," Michael Wales, National Bureau of Standards, Washington, D. C.

Afternoon Session. Chairman: Walter Stockmayer.

"Relation Between Degree of Branching and Degree of Conversion during Polymerization," O. L. Wheeler, Colton Chemical Company, Cleveland, Ohio.

"Branching, Crosslinking, and Popcorn Polymerization in Methyl Acrylate," T. G. Fox, Jr., Rohm & Haas Company, Philadelphia, Penna.

"The Chemistry of Derived Polymers," W. O. Kenyon, Eastman Kodak Company, Rochester, N. Y.

"Branching of Polycarbohydrates," Charles O. Beckmann, Columbia University, New York, N. Y.

Saturday, January 10

Morning Session. Chairman: W. O. Kenyon.

"Branching in Polyethylene," F. M. Rugg, Bakelite Company, Bloomfield, N. J.

"Branching in Polyvinyl Chloride," J. D. Cotman, Monsanto Chemical Company, Springfield, Mass.

"Branching of Dienes," Maurice Morton, University of Akron, Akron, Ohio.

"Conclusions Concerning the Effects of Branching, with Special Reference to Mechanical Behavior," H. Mark, Institute of Polymer Research, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

SECTION OF BIOLOGY

"PARENTAL AGE AND CHARACTERISTICS OF THE OFFSPRING"

JANUARY 23 AND 24, 1953

The Section of Biology held a Conference on "Parental Age and Characteristics of the Offspring." Doctor Leonell C. Strong, Yale University School of Medicine, New Haven, Conn., was the Conference Chairman in charge of the meeting.

The program consisted of the following papers.

Friday, January 23

Morning Session.

"Opening Remarks," E. V. Cowdry, Washington University, St. Louis, Mo.

"A Nongenic Factor in the Longevity of Rotifers," A. I. Lansing, Washington School of Medicine, St. Louis, Mo.

"Influence of Maternal Age on Penetrance of 'Eyelid Open' (0) in C_3H Strong Mice," T. S. Hauschka and Elizabeth Brown, Institute for Cancer Research, Philadelphia, Pennsylvania.

"Meristem Ageing," E. Ashby and Dr. Wangermann, Queens University, Belfast, North Ireland.

"The Ageing of Plants and Germinative Qualities of their Seed," E. E. Bünning, University of Tübingen, Tübingen, Germany.

"The Ageing of Seeds and Mutation Rates," A. F. Blakeslee, Smith College, Northampton, Mass.

"Review of Wright's Correlation of Guinea Pig Spotting Pattern," Morris Foster, Yale University School of Medicine, New Haven, Conn.

Afternoon Session.

"Mongolian Idiocy and Maternal Age," L. S. Penrose, University College, London, England.

"Congenital Malformations and Parental Age," D. F. Murphy, University of Pennsylvania, Philadelphia, Pennsylvania.

"The Cumulative Effect of Litter Seriation on Fibrosarcoma Susceptibility in Mice," L. C. Strong, Yale University School of Medicine, New Haven, Conn.

"Effects on the Offspring of Altered Physiologic States during Pregnancy in the Rat," J. C. Wilson, University of Cincinnati Medical School, Cincinnati, Ohio.

"The Effects on Development when Eggs and Sperm Are Aged before Fertilization," R. J. Blandau, University of Washington, Seattle, Washington.

"The Effects of the Age of the Mother on the Sex Ratio at Birth in Japan," E. E. Takahashi, Hirosaki University, Hirosaki, Japan.

Saturday, January 24

Morning Session.

"The Problem of Mongolism," T. H. Ingalls, Harvard School of Public Health, Boston, Mass.

"Influence of Maternal Age on Development of the Skeleton of the Mouse," Hans Grüneberg and A. G. Searle, University College, London, England.

"The Influence of Age of Mother on Pattern of Reproduction," P. B. Sawin, Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine.

"Maternal Influence on Experimental Leukemia in Mice," L. W. Law, National Cancer Institute, Bethesda, Maryland.

"The Influence of Maternal Age on Immunity of Offspring: Some General Considerations," H. P. Treffers, Yale University School of Medicine, New Haven, Conn.

Afternoon Session.

"Search for New Cases of Parental and Seasonal Influences upon Variations within Inbred Strains," Elizabeth S. Russell, Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine.

"The Effects of Altered Environment and of Age on Mother–Young Relationships Among Animals," Bernard F. Reiss, Hunter College, New York, N. Y.

General Discussion

"Concluding Remarks," E. V. Cowdry, Washington University, St. Louis, Mo.

The Section of Physics and Chemistry and the Section of Biology provide conferences for active workers in the special fields of Physics and Chemistry and the field of Biology, respectively.

Attendance is limited to those invited to participate in these conferences and to interested Members of the Academy.

NEW MEMBERS

Elected January 22, 1953

SUSTAINING MEMBERSHIP

Cameron, Charles Sherwood, M.D., Cancer. Medical & Scientific Director and Vice-President, American Cancer Society Inc., New York, N. Y.

Lawler, Richard H., M.D., Surgery. Senior Attending Surgeon, Cook County Hospital, Chicago, Ill.

ACTIVE MEMBERSHIP

Abrahams, Irving, Ph.D., Immunology. Assistant Director, Division of Laboratories and Research, Nassau County Department of Health, Mineola, L. I., N. Y.

Albert, Roy Ernest, M.D., Medicine. Medical Officer, Atomic Energy Commission, New York, N. Y.

Alexander, Robert B., M.D., Heart Diseases. Staff, Mt. Zion Hospital, San Franciso, Calif.

Ambrose, John Frederic, Ph.D., High Polymers. Member of Technical Staff, Bell Telephone Laboratories, Murray Hill, N. J.

Anderson, Elizabeth Potts, Ph.D., Biochemistry. Assistant Research Professor, Dept. of Pharmacology, George Washington University, Washington, D. C.

Apton, Adolph A., M.D., Psychology. Mt. Sinai Hospital, New York, N. Y.

Aston, E. C., D.D.S., Psychology. Private Practice, Dentistry, West New York, N. J.

Baeder, David Harry, Ph.D., Pharmacology. Pharmacologist, Wyeth Institute of Applied Biochemistry, Philadelphia, Pa.

Bailey, Charles Philamore, M.D., Thoracic Surgery. Professor and Head, Department of Thoracic Surgery, Hahnemann Medical College, Philadelphia, Pa.

Baram, Peter, M.S., Bacteriology. Graduate Student, Chicago, Ill.

Barban, Stanley, Ph.D., Bacterial Metabolism. Instructor of Bacteriology, State Univ., of New York, Syracuse, N. Y.

Barker, Harold Grant, M.D., Renal Physiology. Associate in Surgery, University of Pennsylvania, Philadelphia, Pa.

Bartlett, W. W., Ph.D., Physics, Electronics. Chief, Research Division, U. S. Naval Underwater Ordnance Station, Newport, R. I.

Baylin, George J., M.D., Radiology. Professor of Radiology, Duke Hospital, Durham, N. C.

Beardmore, William B., M.S., Bacteriology. Assistant Instructor, Department of Bacteriology, Ohio State University, Columbus, Ohio.

Beasley, John K., Ph.D., Polymer Chemistry. Research Chemist, Du Pont Experimental Station, Wilmington, Del.

Beck, Marcus, M.D., Tissue Pathology. Resident, Letterman Army Hospital, San Francisco, Calif.

Beckman, Edward L., M.D., Physiology. Acting Research Director, Aviation Medical Acceleration Lab., Johnsville, Pa.

Berg, Murray, D.D.S., Dentistry. Field Dentist, New York City Health Department, N. Y.

Berke, Rudolph, M.D., Internal Medicine. Physician, Veterans Administration Hospital, New York, N. Y.

Bilger, Leonora Neuffer, Ph.D., Organic and Biochemistry. Professor of Chemistry and Chairman of Department of Chemistry, University of Hawaii, Honolulu, Hawaii.

Bleir, Ruth, M.D., General Medicine. Private Practice, Baltimore, Md.

Blumberg, Avrom Aaron, B.S., Chemistry. Graduate Student, Yale University, New Haven, Conn.

Bogdanove, Emanuel M., M.S., Endocrinology. Teaching Fellow, Department of Anatomy, State University of Iowa, Iowa City, Iowa.

Bogner, Robert Leonard, Ph.D., Pharmacology. Associate Professor of Pharmacology. St. John's University, Brooklyn, N. Y.

Boruchoff, Arthur, M.D., Ophthalmology. Resident Physician, New York Eye and Ear Infirmary, New York, N. Y.

Bozeman, Samuel R., Ph.D., Biologic Products. Director, Biological Laboratories, Pitman-Moore Company, Indianapolis, Ind.

Breedis, Charles, M.D., Cancer. Assistant Professor of Experimental Pathology, University of Pennsylvania, Philadelphia, Pa.

Brehm, Warren J., Ph.D., Organic Chemistry. Research Chemist, Dept. of Polychemicals, E. I. Du Pont de Nemours & Co., Wilmington, Del.

Brown, Harold, M.D., Metabolism. Chief, Medical Service, Veterans Administration Hospital, Salt Lake City, Utah.

Budgen, Harry Percival, Ph.D., Bridges. Managing Director, Stothert and Pitt (Canada) Ltd., Montreal, Canada.

Camien, Merrill N., Ph.D., Biochemistry. Research Fellow in Biochemistry, University of California, Los Angeles, Calif.

Chalfin, David, B.S., General Physiology. Grad. Student, Natural Science Foundation Fellow, Dept. of Biology, Princeton Univ., Princeton, N. J.

Claesson, Stig Melker, Ph.D., Physical Chemistry. Professor of Physical Chemistry, University of Uppsala, Uppsala, Sweden.

Clark, Irwin, Ph.D., Biochemical Sciences. Research Associate, Head, Isotope Dept., Merck Inst., Rahway, N. J.

Cochran, Kenneth W., Ph.D., Pharmacology. Research Associate, Department of Epidemiology, University of Michigan, Ann Arbor, Mich.

Colton, Maxwell B., D.D.S., Bacteriology. Private Practice, New York, N. Y.

Conkling, Frank W., B.S., Cosmic Research. Manager, Research Division, Airkem Inc., New York, N. Y.

Conston, Alfred S., M.D., Pathology. Director of Laboratories, West Jersey Hospital, Camden, N. J.

Conti, Carlo, M.D., General Medicine, Endocrinology. Research Assistant of the Institute of Experimental Medicine and Surgery, University of Montreal, Canada.

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